

A

12/22/98
JCS16 U.S. PTO

UTILITY PATENT APPLICATION TRANSMITTAL <i>Submit an original and a duplicate for fee processing</i> <i>(Only for new nonprovisional applications under 37 CFR 1.53(b))</i>									
ADDRESS TO: Assistant Commissioner for Patents Box Patent Application Washington, D.C. 20231	<table style="width:100%; border: none;"> <tr> <td style="border: none;">Attorney Docket No.</td> <td style="border: none;">98,736</td> </tr> <tr> <td style="border: none;">First Named Inventor</td> <td style="border: none;">Roderick L. Hall</td> </tr> <tr> <td style="border: none;">Express Mail No.</td> <td style="border: none;">EL 109479391</td> </tr> <tr> <td style="border: none;">Total Pages</td> <td style="border: none;">117</td> </tr> </table>	Attorney Docket No.	98,736	First Named Inventor	Roderick L. Hall	Express Mail No.	EL 109479391	Total Pages	117
Attorney Docket No.	98,736								
First Named Inventor	Roderick L. Hall								
Express Mail No.	EL 109479391								
Total Pages	117								
APPLICATION ELEMENTS 1. <input checked="" type="checkbox"/> Transmittal Form with Fee 2. <input checked="" type="checkbox"/> Specification (including claims and abstract) [Total Pages 76] 3. <input checked="" type="checkbox"/> Drawings [Total Sheets 41] 4. <input type="checkbox"/> Oath or Declaration [Total Pages] a. <input type="checkbox"/> Newly executed b. <input type="checkbox"/> Copy from prior application [Note Boxes 5 and 17 below] i. <input type="checkbox"/> Deletion of Inventor(s) Signed statement attached deleting inventor(s) named in the prior application 5. <input type="checkbox"/> Incorporation by Reference: The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein. 6. <input type="checkbox"/> Microfiche Computer Program 7. <input type="checkbox"/> Nucleotide and/or Amino Acid Sequence Submission a. <input type="checkbox"/> Computer Readable Copy b. <input type="checkbox"/> Paper Copy c. <input type="checkbox"/> Statement verifying above copies	ACCOMPANYING APPLICATION PARTS 8. <input type="checkbox"/> Assignment Papers 9. <input type="checkbox"/> Power of Attorney 10. <input type="checkbox"/> English Translation Document (if applicable) 11. <input type="checkbox"/> Information Disclosure Statement (IDS) <input type="checkbox"/> PTO-1449 Form <input type="checkbox"/> Copies of IDS Citations 12. <input type="checkbox"/> Preliminary Amendment 13. <input checked="" type="checkbox"/> Return Receipt Postcard (Should be specifically itemized) 14. <input type="checkbox"/> Small Entity Statement(s) <input type="checkbox"/> Enclosed <input type="checkbox"/> Statement filed in prior application; status still proper and desired 15. <input type="checkbox"/> Certified Copy of Priority Document(s) 16. <input type="checkbox"/> Other:								
17. If a CONTINUING APPLICATION , check appropriate box and supply the requisite information: <input type="checkbox"/> Continuation <input type="checkbox"/> Divisional <input type="checkbox"/> Continuation-in-part of prior application Serial No.									

JCS16 U.S. PTO
09/21/99
12/22/98

09213913 12/22/98

APPLICATION FEES				
BASIC FEE				\$790.00
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total Claims	45 -20=		25 x \$22.00	\$550.00
Independent Claims	2 -3=		x \$ 82.00	\$0
<input checked="" type="checkbox"/> Multiple Dependent Claims(s) if applicable			+\$270.00	\$270.00
Total of above calculations =				\$
Reduction by 50% for filing by small entity =				\$()
<input type="checkbox"/> Assignment fee if applicable			+ \$40.00	\$
TOTAL =				\$1610.00

UTILITY PATENT APPLICATION TRANSMITTAL


Attorney Docket No. 98,736

18. ☐ Please charge my Deposit Account No. 13-2490 in the amount of \$.
19. ☐ A check in the amount of \$ is enclosed.
20. The Commissioner is hereby authorized to credit overpayments or charge any additional fees of the following types to Deposit Account No. 13-2490:
- a. ☐ Fees required under 37 CFR 1.16.
 - b. ☐ Fees required under 37 CFR 1.17.
 - c. ☐ Fees required under 37 CFR 1.18.
21. ☒ The Commissioner is hereby generally authorized under 37 CFR 1.136(a)(3) to treat any future reply in this or any related application filed pursuant to 37 CFR 1.53 requiring an extension of time as incorporating a request therefor, and the Commissioner is hereby specifically authorized to charge Deposit Account No. 13-2490 for any fee that may be due in connection with such a request for an extension of time.

22. CORRESPONDENCE ADDRESS

Name	McDonnell Boehnen Hulbert & Berghoff
Address	32 nd Floor, 300 South Wacker Drive
City, State, Zip	Chicago, Illinois 60606

23. SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Name	Emily Miao Reg. No. 35,285
Signature	
Date	Dec. 22, 1998

UTILITY (Rev. 11/18/97)

Method for Accelerating the Rate of Mucociliary Clearance

5 Field of the Invention

The present invention relates to compositions comprising serine protease inhibitor proteins which stimulate the rate of mucociliary clearance of mucus and sputum in lung airways. The present invention also relates to methods for stimulating the rate of mucociliary clearance in mammals.

10

Background of the Invention

Problem Addressed

Mucociliary dysfunction, characterized by the inability of ciliated
15 epithelium to clear mucus and sputum in lung airways, is a serious complication of chronic obstructive lung diseases such as Chronic Bronchitis (CB), Bronchiectasis (BE), asthma and, especially, Cystic Fibrosis (CF). Patients suffering from mucociliary dysfunction are particularly vulnerable to secondary bacterial infections. Treatment and maintenance modalities for CF and other
20 respiratory diseases associated with mucociliary dysfunction and the need for improved treatments have been described. See, for instance, Braga "Drugs in Bronchial Mucology, Raven Press, New York, 1989; Lethem et al, Am Rev. Respir. Dis. 142:1053-1058, 1990; U.S. Patent No. 5,830,436..

25 *Cystic Fibrosis*

Cystic fibrosis (CF) is an autosomal recessive disease that causes abnormalities in fluid and electrolyte transport in exocrine epithelia. Mutations within the DNA coding for a protein termed the cystic fibrosis transmembrane conductance regulator (CFTR) have been found in virtually all CF patients. Cells
30 of the lung are particularly affected. Di Santagrese et al, Am J. Med. 66: 121-132 (1979).

In CF, the luminal border of the airway mucosal cell is unresponsive to cAMP-dependant protein kinase activation of membrane chloride ion channels. The cell permeability to Cl^- is impaired and Na^+ absorption across the cell
35 membrane is accelerated. Both of these electrolyte imbalances tend to reduce the level of hydration of the airway mucus thus contributing to the viscous lung secretions characteristic of CF. Knowles, Clin. Chest. Med. 11: 75 (1986).

Adventitious bacteria and mycoplasmas enter the lung airways and establish colonies within the mucus. The thick mucus associated with CF isolates these pathogens from the immune system. Since mucociliary clearance is reduced in CF patients, bacterial clearance is also reduced. Lung congestion and infection are thus common. The prolonged presence of these pathogenic agents invariably initiates inflammatory reactions that compromise lung function. Bedrossian et al., *Human Pathol.* 7:195-204, 1976.

Mucus viscosity in CF lungs is in part due to the decreased hydration of the mucus as related to Cl⁻ channel malfunction and modification of sodium (Na⁺) ion concentration in the airway surface liquid (ASL) that change the rate of airway mucociliary clearance (MCC). The mechanisms involved in mucus transport have been studied in vitro and in vivo. CB, CF, and BE sputa are transported slowly by the mammalian ciliated epithelium of the mucus depleted bovine trachea (MDBT) (Wills et al, *J. Clin. Invest.* 97(1): 9-13, 1995). Slow transportability of diseased sputum on the MDBT may be linked to its low electrolyte/osmolyte content (Wills et al, *J. Resp. Crit. Care Med.* 151(4): 1255-1258, 1997). Indeed, diseased sputum is known to have low electrolyte content relative to plasma (Matthews et al, *Am. Rev. Resp. Dis.* 88: 199-204, 1963 ; Potter et al, *Am. Rev. Resp. Dis.* 67(1): 83-87, 1967 ; Tomkiewicz et al, *Am. Rev. Resp. Dis.* 148(4, Pt. 1): 1002-1007, 1993).

Further studies on the MDBT have shown that transportability of diseased mucus is markedly improved following treatment with sodium chloride (Wills et al 1995). Furthermore, clinical studies have shown that inhalation of hypertonic saline, or of the epithelial sodium channel (ENaC) blocker amiloride can significantly increase MCC in diseased patients (Robinson et al, *Thorax* 52(10): 900-903, 1997; App et al, *Am. Rev. Resp. Dis.* 141, 605-612, 1990). Recently, the relationship between mucus clearance and its ionic composition in vivo in the guinea-pig model of tracheal mucus velocity (TMV) has been elucidated. In vivo studies showed that a 5 minute aerosol of hypertonic saline transiently increased TMV. An increase in TMV was observed 1 min after hypertonic saline (14.4%) aerosol. TMV was 5.1 ± 1.0 mm.min⁻¹ (n=9) in 0.9% saline-exposed animals compared to 11.3 ± 1.3 mm.min⁻¹ in hypertonic saline exposed animals (n=9; p<0.001)(Newton & Hall, 1997). Inhaled amiloride also caused an increase in TMV. A significant increase in TMV was observed 15 minutes after a 20 minute aerosol of amiloride (10mM). TMV was 3.2 ± 2.5 mm.min⁻¹ (n=9) in water-exposed animals compared to 8.1 ± 0.3 mm.min⁻¹ in amiloride-exposed animals (n=8; p<0.05) Newton et al, *Ped. Pulm.* S17, Abs. 364,

1998). These agents would appear to act by increasing the ionic content of airway surface liquid (ASL).

Recently, a serine protease termed channel activating protease-1 (CAP-1) has been found in the apical membrane of amphibian *Xenopus* kidney epithelial cells (A6 cells) (Vallet et al, *Nature* 389(6651): 607-610, 1997). CAP-1 appears to modulate Na⁺ channel activity in these cells. Exposure of the apical membrane to the prototypical bovine Kunitz inhibitor, aprotinin, reduced transepithelial Na⁺ transport (Vallet et al 1997 : Chraïbi et al, *J. Gen. Physio.* 111(1): 127-138, 1998). The effect of Bukinin, a two Kunitz domain human homologue of bovine aprotinin (Delaria et al, *J. Biol. Chem.* 272(18): 12209-12214, 1997; Marlör et al, *J. Biol. Chem.* 272(18): 12202-12208, 1997), was evaluated using normal cultured human bronchial epithelial cell (HBE) short circuit current (Isc) in vitro (McAulay et al, *Ped. Pulm.* S17, Abs. 141, 1998). Bikunin (1.5ug.ml⁻¹ : 70nM) significantly inhibited 54% Na⁺ Isc in normal HBE cells (n=5-8 ; p≤0.05). Overall, Bikunin (70nM) inhibited 58% of the baseline Isc in 90 minutes. In a further study, Bikunin (5ug.ml⁻¹) significantly inhibited 84% Na⁺ Isc in normal HBE cells (n=6; p≤0.01) whilst the serpin-family serine protease inhibitor alpha(1)-protease inhibitor (α₁-PI)(50 ug.ml⁻¹) was without a significant effect.

Two recent studies by a single research group have demonstrated a protease inhibitor induced effect on TMV. α₁-PI (10mg) given either 30 min before antigen challenge, or 1 h after challenge, attenuated antigen-induced reduction in TMV in allergic sheep, 6h after challenge (O’Riordan et al, *Am. J. Resp. Crit. Care Med.* 97(5): 1522-1528, 1997). In Fig 1 in the O’Riordan et al 1997 paper, the authors showed that α₁-PI administered on its own (no antigen challenge) to the airways of allergic sheep, had no effect on baseline TMV over a 6h period. In the second study, α₁-PI was given 6 h after antigen challenge and caused only a significant reversal of the antigen-induced fall in TMV at 24 h after challenge (O’Riordan et al, *J. App. Physio.* 85(3): 1086-1091, 1998). The authors argue that the mechanism for the effect of α₁-PI is associated with its anti-neutrophil elastase property, where neutrophil elastase is believed to be the enzyme responsible for the reduced rate of mucociliary clearance in their model. They reasoned that α₁-PI could be used to treat mucociliary dysfunction brought about by allergy-induced neutrophil elastase release in asthma (O’Riordan et al 1998); they did not speculate on a potential role in other respiratory diseases.

Brief Summary of the Invention

The instant invention is directed to the use of Kunitz-family serine protease inhibitors that stimulate the rate of mucociliary clearance (MCC) of mucus and sputum in the airways of the lung. Kunitz-serine protease inhibitors could be used to treat lung diseases such as Cystic Fibrosis (CF), Chronic Bronchitis (CB) and Bronchiectasis (BE) where the retention and accumulation of mucus is a major clinical problem. Until now, prior art has not associated protease inhibitors with the ability to increase the rate of MCC above baseline rate. Kunitz-type serine protease inhibitors could also be used to treat chronic sinusitis and glue ear where the retention and accumulation of mucus is a clinical problem.

The instant invention contemplates the use of serine protease inhibitors proteins which include Kunitz domains or Kunitz-like domains for use in a method for stimulating MCC. In one embodiment of the invention, bovine serine protease inhibitor proteins such as aprotinin and variants and fragments thereof such as the ones described in EP 821007, published January 28, 1998, may be used in practicing the invention.

In another embodiment of the invention, human serine protease inhibitors are contemplated for use in the method for stimulating the rate of MCC.

Representative examples of human serine protease inhibitors include Bikunin and variants and fragments thereof such as the ones described in WO 97/33996, published September 18, 1997 (Bayer Corp.), and U.S. Patent No. 5,407,915, issued April 18, 1995 (Bayer AG) which are incorporated herein in its entirety.

Description of the Drawings

The invention will be better understood from a consideration of the following detailed description and claims, taken in conjunction with the drawings, in which:

Figure 1 depicts the nucleotide sequence of EST R35464 (SEQ ID NO.: 12) and the translation of this DNA sequence (SEQ ID NO.: 13) which yielded an open reading frame with some sequence similarity to aprotinin. The translation product contains 5 of the 6 cysteines in the correct spacing that is characteristic for Kunitz-like inhibitor domains (indicated in bold). The position normally occupied by the remaining cysteine (at codon 38) contained instead a phenylalanine (indicated by an asterisk).

Figure 2 depicts the nucleotide sequence of EST R74593 (SEQ ID NO.: 14), and the translation of this DNA sequence (SEQ ID NO.: 15) which yielded an open reading frame with homology to the Kunitz class of serine protease

inhibitor domains. The translation product contained 6 cysteines in the correct spacing that is characteristic for Kunitz-like inhibitor domains (indicated in bold). However, this reading frame sequence includes stop codons at codon 3 and 23.

Figure 3 depicts a deduced nucleic acid sequence of human placental bikunin (SEQ ID NO.: 9) labeled "consensus" and matched with the translated protein amino acid sequence labeled "translated" (SEQ ID NO.: 10). Also as comparison are shown the nucleic acid sequence for ESTs H94519 (SEQ ID NO.: 16), N39798 (SEQ ID NO.: 17), R74593 (SEQ ID NO.: 14) and R35464 (SEQ ID NO.: 12). The underlined nucleotides in the consensus sequence correspond to the site of PCR primers described in the Examples. Underlined amino acids in the translated consensus sequence are residues whose identity have been confirmed by amino acid sequencing of purified native human placental bikunin. Nucleotide and amino acid code are standard single letter code, "N" in the nucleic acid code indicates an unassigned nucleic acid, and "*" indicates a stop codon in the amino acid sequence.

Figure 4A depicts the original overlay of a series of ESTs with some nucleic acid sequence homology to ESTs encoding human placental bikunin, or portions thereof. Shown for reference are the relative positions of bikunin (7-64) and bikunin (102-159), labeled KID1 and KID2 respectively.

Figure 4B depicts a subsequent more comprehensive EST overlay incorporating additional ESTs. Numbers on the upper X-axis refer to length in base pairs, starting at the first base from the most 5' EST sequence. The length of each bar is in proportion to the length in base pairs of the individual ESTs including gaps. The EST accession numbers are indicated to the right of their respective EST bars.

Figure 4C depicts the corresponding alignment of the oligonucleotide sequences of each of the overlapping ESTs shown schematically in Figure 4B. The upper sequence (SEQ ID NO.: 51) labeled bikunin represents the consensus oligonucleotide sequence derived from the overlapping nucleotides at each position. The numbers refer to base-pair position within the EST map. The oligonucleotides in EST R74593 that are bold underlined (at map positions 994 and 1005) are base insertions observed in R74593 that were consistently absent in each of the other overlapping ESTs.

Figure 4D depicts the amino acid translation of the consensus oligonucleotide sequence for bikunin depicted in Figure 4C (SEQ ID NO.: 45).

Figure 4E depicts the nucleotide sequence (SEQ ID NO.: 46) and

corresponding amino acid translation (SEQ ID NO.: 47) of a placental bikunin encoding sequence that was derived from a human placental cDNA library by PCR-based amplification.

Figure 4F depicts the nucleotide sequence (SEQ ID NO.: 48) and corresponding amino acid translation (SEQ ID NO.: 49) of a native human placental bikunin encoding clone that was isolated from a human placental lambda cDNA library by colony hybridization.

Figure 4G compares the alignment of the amino acid translated oligonucleotide sequences for placental bikunin obtained by EST overlay (SEQ ID NO.: 45), PCR based cloning (SEQ ID NO.: 47), and conventional lambda colony hybridization (SEQ ID NO.: 49).

Figure 5 shows a graph of purification of human placental bikunin from placental tissue after Superdex 75 Gel-Filtration. The plot is an overlay of the protein elution profile as measured by OD 280 nm (solid line), activity of eluted protein in a trypsin inhibition assay (% inhibition shown by circles), and activity of eluted protein in a kallikrein inhibition assay (% inhibition shown by squares).

Figure 6 shows a graph which plots the purification of human placental bikunin from placental tissue using C18 Reverse-Phase Chromatography. The plot is an overlay of the protein elution profile as measured by OD 215 nm (solid line), activity of eluted protein in a trypsin inhibition assay (% inhibition shown by circles), and activity of eluted protein in a kallikrein inhibition assay (% inhibition shown by squares).

Figure 7 depicts a silver stained SDS-PAGE gel of highly purified placental bikunin (lane 2), and a series of molecular size marker proteins (lane 1) of the indicated sizes in kilodaltons. Migration was from top to bottom.

Figure 8 shows the amount of trypsin inhibitory activity present in the cell-free fermentation broth from the growth of yeast strains SC101 (panel 8A) or WHL341 (panel 8B) that were stably transformed with a plasmid (pS604) that directs the expression of placental bikunin (102-159).

Figure 9 shows both a silver stained SDS-PAGE (left panel) and a Western blot with anti-placental bikunin (102-159) pAb (right panel) of cell-free fermentation broth from the growth of yeast strain SC101 (recombinants 2.4 and 2.5) that was stably transformed with a plasmid directing the expression of either bovine aprotinin, or placental bikunin (102-159). Migration was from top to bottom.

Figure 10 is a photograph which shows a silver stained SDS-PAGE of highly purified placental bikunin (102-159) (lane 2) and a series of molecular size marker proteins (lane 1) of the indicated sizes in Kilodaltons. Migration was

from top to bottom.

Figure 11 is a photograph which shows the results of Northern blots of mRNA from various human tissues that was hybridized to a ^{32}P labeled cDNA probe encoding either placental bikunin (102-159) (panel 11A) or encoding placental bikunin (1-213) (panel 11B). Migration was from top to bottom. The numbers to the right of each blot refer to the size in kilobases of the adjacent RNA markers. The organs from which mRNA was derived is described under each lane of the blot.

Figure 12 depicts an immunoblot of placental derived placental bikunin with rabbit antiserum raised against either synthetic reduced placental bikunin (7-64) (panel A) or 102-159 (panel B). For each panel, contents were: molecular size markers (lanes 1); native placental bikunin isolated from human placenta (lanes 2); synthetic placental bikunin (7-64) (lanes 3) and synthetic placental bikunin (102-159) (lanes 4). Tricine 10-20% SDS-PAGE gels were blotted and developed with protein A-purified primary polyclonal antibody (8 ug IgG in 20 ml 0.1% BSA/Tris-buffered saline (pH 7.5), followed by alkaline phosphatase-conjugated goat anti-rabbit secondary antibody. Migration was from top to bottom.

Figure 13 depicts a Coomassie Blue stained 10-20% Tricine SDS-PAGE gel of 3 micrograms of highly purified placental bikunin (1-170) derived from a baculovirus / Sf9 expression system (lane 2). Lane 1 contains molecular size markers. Migration was from top to bottom.

Figure 14 depicts a comparison of the effect of increasing concentrations of either Sf9-derived human placental bikunin (1-170) (filled circles), synthetic placental bikunin (102-159) (open circles), or aprotinin (open squares) on the activated partial thromboplastin time of human plasma. Clotting was initiated with CaCl_2 . The concentration of proteins are plotted versus the -fold prolongation in clotting time. The uninhibited clotting time was 30.8 seconds.

Figure 15 illustrates the effect of Bikunin at dosage levels of 2 uM and 0.2 uM relative to amiloride (100 uM) and Hank's Balanced salt solution (HBSS) vehicle (control) on potential differences in guinea pig trachea 3 hours post-treatment.

Figure 16 illustrates (a) the positioning of the instillment syringe and beta probe relative to the guinea pig trachea; (b) a representative graph for measurement of trachea mean velocity (TMV) using ^{32}P -labelled *S.cerevisiae*; and (c) the sustained increase in TMV in vivo in guinea pig in response to Bikunin (5 ug) relative to HBSS vehicle control at 1.5, 1.75, 2.0, 2.25 and 2.5 hours following tracheal instillment.

Figure 17 illustrates that Bikunin (70 nM) decreases sodium current in cultured human bronchial epithelial cells in vitro relative to amiloride (10 uM).

Figure 18 illustrates the effect of a 5 min aerosol of hypertonic saline (14.4%) on increasing TMV, following aerosol treatment in guinea pig trachea.

Figure 19 illustrates the effect of a 20 minute aerosol of amiloride (10 mM) on TMV, following aerosol treatment in guinea pig trachea.

Figure 20 illustrates that Bikunin (5ug/mL), aprotinin (5 ug/mL), and aprotinin double mutein (0.5 ug/mL, 1.5 ug/mL and 5 ug/mL) decrease sodium short circuit current in cultured human bronchial cells in vitro.

Detailed Description of the Invention

The present invention relates to compositions comprising Kunitz-type serine protease inhibitor proteins and fragments thereof which stimulate the rate of mucociliary clearance of mucus and sputum in lung airways. The compositions also encompass a newly identified human protein herein called human placental bikunin that contains two serine protease inhibitor domains of the Kunitz class.

The present invention also provides methods for stimulating the rate of mucociliary clearance in patients with mucociliary dysfunction, wherein an effective amount of the disclosed serine protease inhibitors of the present invention, in a biologically compatible vehicle, is administered to the patient.

A preferred application for placental bikunin, isolated domains, and other variants is for stimulating mucociliary clearance in CF patients as part of disease therapy and management. These methods and compositions reduce or eliminate mucus and sputum buildup in lung airways in patients with chronic obstructive lung disease, thereby reducing the risk of secondary lung infections and other adverse side effects, as well as avoiding or delaying the need for lung transplant surgery in CF patients.

The method of the present invention contemplates the use of aprotinin to stimulating MCC. Aprotinin has been shown to reduce transepithelial Na⁺ transport in the apical membrane of amphibian *Xenopus* kidney epithelial cells (A6 cells) (Vallet et al 1997 : Chraibi et al 1998). The mechanism of aprotinin action has been proposed to involve inhibition of CAP-1, a protease involved in modulating Na⁺ channel activity in A6 cells. Bikunin, a two Kunitz domain human homologue of bovine aprotinin (Delaria et al 1997 : Marlor et al 1997), was also shown to significantly inhibit normal cultured human bronchial epithelial cell (HBE) short circuit current (Isc) in vitro (McAulay et al 1998). Bikunin (1.5ug.ml⁻¹ : 70nM) significantly inhibited 54% Na⁺ Isc in normal HBE cells (n=5-8 ; p<0.05). Overall, Bikunin (70nM) inhibited 58% of the baseline Isc

in 90 minutes. In a further study, Bikunin (5ug.mL⁻¹) significantly inhibited 84% Na⁺ Isc in normal HBE cells (n=6; p<0.01) whilst the serpin-family serine protease inhibitor alpha(1)-protease inhibitor (α_1 -PI)(50ug.mL⁻¹) was without a significant effect.

5 In light of these observations, Kunitz-type serine inhibitors such as aprotinin, placental bikunin and fragments thereof are contemplated as therapeutics for treating mucociliary dysfunction, including cystic fibrosis.

A significant advantage of the Kunitz domains of the serine protease inhibitor Bikunin and fragments and analogs thereof of the present invention is
10 that they are human proteins, and also less positively charged than Trasylol[®] (Example 1), thereby reducing the risk of kidney damage on administration of large doses of the proteins. Being of human origin, the protein of the instant invention can thus be administered to human patients with significantly reduced risk of undesired immunological reactions as compared to administration of
15 similar doses of Trasylol[®]. Furthermore, it was found that bikunin(102-159), bikunin(7-64), and bikunin(1-170) are significantly more potent inhibitors of plasma kallikrein than Trasylol[®] *in vitro* (Example 3, 4 and 10). Thus bikunin and fragments thereof are expected to be more effective *in vivo* relative to aprotinin.

20 The amount of the pharmaceutical composition to be employed will depend on the recipient and the condition being treated. The requisite amount may be determined without undue experimentation by protocols known to those skilled in the art. Alternatively, the requisite amount may be calculated, based on a determination of the amount of target protease such as plasmin,
25 kallikrein or prostatic which must be inhibited in order to treat the condition. As the active materials contemplated in this invention are deemed to be nontoxic, treatment preferably involves administration of an excess of the optimally required amount of active agent.

For stimulating the rates of mucociliary clearance in patients with chronic
30 obstructive lung disease, the proteins of the instant invention may be used like aprotinin Trasylol[®] while taking into account the differences in potency. The use of Trasylol[®] is outlined in the Physicians Desk Reference, 1995, listing for Trasylol[®] supplement A. Briefly, with the patient in a supine position, the loading dose of placental bikunin, isolated domain or other variant is given by
35 infusion slowly over about 20 to 30 minutes. In general, a total dose of between about 2x10⁶ KIU (kallikrein inhibitory units) and 8 X10⁶ KIU will be used, depending on such factors as patient weight and condition. Preferred loading

doses are those that contain a total of 1 to 2 million kallikrein inhibitory units (KIU).

The proteins of the instant invention are employed in pharmaceutical compositions formulated in the manner known to the art. Such compositions contain active ingredient(s) plus one or more pharmaceutically acceptable carriers, diluents, fillers, binders, and other excipients, depending on the administration mode and dosage form contemplated. Examples of therapeutically inert inorganic or organic carriers known to those skilled in the art include, but are not limited to, lactose, corn starch or derivatives thereof, talc, vegetable oils, waxes, fats, polyols such as polyethylene glycol, water, saccharose, alcohols, glycerin and the like. Various preservatives, emulsifiers, dispersants, flavorants, wetting agents, antioxidants, sweeteners, colorants, stabilizers, salts, buffers and the like can also be added, as required to assist in the stabilization of the formulation or to assist in increasing bioavailability of the active ingredient(s) or to yield a formulation of acceptable flavor or odor in the case of oral, nasal or pulmonary dosing. The inhibitor employed in such compositions may be in the form of the original compound itself, or optionally, in the form of a pharmaceutically acceptable salt. The compositions so formulated are selected as needed for administration of the inhibitor by any suitable mode known to those skilled in the art.

Parenteral administration modes include intravenous (*i.v.*), subcutaneous (*s.c.*), intraperitoneal (*i.p.*), and intramuscular (*i.m.*) routes. Intravenous administration can be used to obtain acute regulation of peak plasma concentrations of the drug as might be needed. Alternatively, the drug can be administered at a desired rate continuously by *i.v.* catheter. Suitable vehicles include sterile, non-pyrogenic aqueous diluents, such as sterile water for injection, sterile-buffered solutions or sterile saline. The resulting composition is administered to the patient prior to and/or during surgery by intravenous injection or infusion.

Improved half life and targeting of the drug to phagosomes such as neutrophils and macrophage involved in inflammation may be aided by entrapment of the drug in liposomes. It should be possible to improve the selectivity of liposomal targeting by incorporating into the outside of the liposomes ligands that bind to macromolecules specific to target organs/tissues such as the GI tract and lungs. Alternatively, *i.m.* or *s.c.* deposit injection with or without encapsulation of the drug into degradable microspheres (e.g., comprising poly-DL-lactide-co-glycolide) or protective formulations containing

collagen can be used to obtain prolonged sustained drug release. For improved convenience of the dosage form it is possible to use an i.p. implanted reservoir and septum such as the percuseal system. Improved convenience and patient compliance may also be achieved by use of either injector pens (e.g., the Novo Pin or Q-pen) or needle-free jet injectors (e.g., from Bioject, Mediject or Becton Dickinson). Precisely controlled release can also be achieved using implantable pumps with delivery to the desired site via a cannula. Examples include the subcutaneously implanted osmotic pumps available from ALZA such as the ALZET osmotic pump.

Oral delivery may be achieved by incorporating the drug into tablets, coated tablets, dragées, hard and soft gelatin capsules, solutions, emulsions, suspensions or enteric coated capsules designed to release the drug into the colon where digestive protease activity is low. Examples of the latter include the OROS-CT/Osmet™ system of ALZA, and the PULSINCAP™ system of Scherer Drug Delivery Systems. Other systems use azo-crosslinked polymers that are degraded by colon-specific bacterial azoreductases, or pH sensitive polyacrylate polymers that are activated by the rise in pH in the colon. The above systems may be used in conjunction with a wide range of available absorption enhancers. Rectal delivery may be achieved by incorporating the drug into suppositories.

Nasal delivery may be achieved by incorporating the drug into bioadhesive particulate carriers (<200 mm) such as those comprising cellulose, polyacrylate or polycarbophil, in conjunction with suitable absorption enhancers such as phospholipids or acylcarnitines. Commercially available systems include those developed by Dan Biosys and Scios Nova.

For stimulating the rate of mucociliary clearance, the preferred mode of administration of the placental bikunin variants of the present invention is pulmonary delivery. The Kunitz-type serine protease inhibitors disclosed herein may be administered to the lungs of a subject by any suitable means, but are preferably administered by administering an aerosol suspension of respirable particles comprised of the active compound, which the subject inhales. The respirable particles may be liquid or solid. Micron-sized dry powders containing the medicament in a suitable carrier such as mannitol, sucrose or lactose may be delivered to the lung airway surface using dry powder inhalers such as those of Inhale™, Dura™, Fisons (Spinhaler™), and Glaxo (Rotahaler™), or Astra (Turbohaler™) propellant based metered dose inhalers. Solution formulations with or without liposomes may be delivered using nebulizers.

Aerosols of liquid particles comprising the proteins may be produced by

any suitable means, such as with a pressure-driven aerosol nebulizer or an ultrasonic nebulizer. See, e.g., U.S. Pat. No. 4,501,729. Nebulizers are commercially available devices which transform solutions or suspensions of the active ingredient into a therapeutic aerosol mist either by means of acceleration of compressed gas, typically air or oxygen, through a narrow venturi orifice or by means of ultrasonic agitation. Suitable formulations for use in nebulizers consist of the active ingredient in a liquid carrier. The carrier is typically water (and most preferably sterile, pyrogen-free water) or a dilute aqueous alcoholic solution, preferably made isotonic with body fluids by the addition of, for example, sodium chloride. Optional additives include preservatives if the formulation is not made sterile, for example, methyl hydroxybenzoate, antioxidants, flavoring agents, volatile oils, buffering agents and surfactants.

Aerosols of solid particles comprising the protein may likewise be produced with any solid particulate medicament aerosol generator. Aerosol generators for administering solid particulate medicaments to a subject produce particles which are respirable, as explained above, and generate a volume of aerosol containing a predetermined metered dose of a medicament at a rate suitable for human administration. One illustrative type of solid particulate aerosol generator is an insufflator. Suitable formulations for administration by insufflation include finely comminuted powders which may be delivered by means of an insufflator or taken into the nasal cavity in the manner of a snuff. In the insufflator, the powder (e.g., a metered dose thereof effective to carry out the treatments described herein) is contained in capsules or cartridges, typically made of gelatin or plastic, which are either pierced or opened in situ and the powder delivered by air drawn through the device upon inhalation or by means of a manually-operated pump. The powder employed in the insufflator consists either solely of the protein or of a powder blend comprising the protein, a suitable powder diluent, such as lactose, and an optional surfactant. A second type of illustrative aerosol generator comprises a metered dose inhaler. Metered dose inhalers are pressurized aerosol dispensers, typically containing a suspension or solution formulation of the active ingredient in a liquified propellant. During use these devices discharge the formulation through a valve adapted to deliver a metered volume, typically from 10 to 200 uL, to produce a fine particle spray containing the protein. Suitable propellants include certain chlorofluorocarbon compounds, for example, dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane and mixtures thereof. The formulation may additionally contain one or more co-solvents, for example,

ethanol, surfactants, such as oleic acid or sorbitan trioleate, antioxidants and suitable flavoring agents.

For metered dose inhaler or dry powder inhaler devices, the aerosol, whether formed from solid or liquid particles, may be produced by the aerosol generator at a rate of from about 5 to 150 liters per minute, more preferably from about 10 to 100 liters per minute, and most preferably for metered dose inhalers from about 10 to 50 liters per minute, and most preferably for dry powder inhalers about 60 liters per minute. Aerosols generated by nebulizer, jet or ultrasonic, may be produced by the aerosol generator at a rate of from about 1 to 100 liters per minute, more preferably from about 4 to 10 liters per minute. Aerosols containing greater amounts of protein may be administered more rapidly.

The dosage of the protease inhibitor will vary depending on the condition being treated and the state of the subject. The daily dose may be divided among one or several unit dose administrations. The daily dose by weight may range from about 0.1 to 20 milligrams of respirable particles for a human subject, depending upon the age and condition of the subject.

Solid or liquid particulate pharmaceutical formulations containing protease inhibitors of the present invention should include particles of respirable size: that is, particles of a size sufficiently small to pass through the mouth and larynx upon inhalation and into the bronchi and alveoli of the lungs. In general, particles ranging from about 1 to 8 microns in size (more particularly, less than about 6 microns in size) are respirable. Particles of non-respirable size which are included in the aerosol tend to be deposited in the throat and swallowed, and the quantity of non-respirable particles in the aerosol is preferably minimized. For nasal administration, a particle size in the range of 10-500 microns is preferred to ensure retention in the nasal cavity.

In the manufacture of a formulation according to the invention, the protease inhibitor is typically admixed with, inter alia, an acceptable carrier. The carrier must, of course, be acceptable in the sense of being compatible with any other ingredients in the formulation and must not be deleterious to the patient. The carrier may be a solid or a liquid, or both, and is preferably formulated with the compound as a unit-dose formulation, for example, a capsule, which may contain from 0.5% to 99% by weight of the active compound. One or more active compounds may be incorporated in the formulations of the invention, which formulations may be prepared by any of the well-known techniques of pharmacy consisting essentially of admixing the components.

Compositions containing respirable dry particles of protease inhibitor may be prepared by grinding the inhibitor with a mortar and pestle, and then passing the micronized composition through a 400 mesh screen to break up or separate out large agglomerates.

5 The pharmaceutical composition may optionally contain a dispersant which serves to facilitate the formation of an aerosol. A suitable dispersant is lactose, which may be blended with the active agent in any suitable ratio (e.g., a 1 to 1 ratio by weight).

10 If desired, general ex vivo and in vivo gene therapy strategies may employed to deliver nucleic acid constructs encoding Kunitz-type serine protease inhibitor proteins such as Bikunin, Aprotinin or fragments and variants thereof such as the ones described in WO 97/33996 (Bayer Corp.) and U.S. Patent No. 5,407,915.(Bayer AG). Gene therapy techniques that are primarily virus-based have been used to transform pulmonary cells as a means for treating
15 the manifestations of CF in the lung and associated extrapulmonary tissues. See WO 93/03709, published March 3, 1993 which describes the use of retroviral and non-retroviral vectors (e.g., adenoviruses and adeno-associated viruses) for the stable expression of the CFTR gene in CF patients. Alternatively, non-viral methods for delivery of exogenous nucleic acids are also known and are
20 contemplated for use in the instant invention. See WO 93/12240, published June 24, 1993 and references cited therein, describing a transcription or expression cassettes including the coding sequence for a CFTR molecule operably joined to regulatory sequences functional in a mammal. The nucleic acids constructs are then supplied to the airways and alveoli of the lung in a number of ways
25 including aerosolized delivery alone or in combination with lipid-based complexes, e.g., Lipofectin.TM WO 95/26356, published October 5, 1995 describes representative examples of lipids useful for transfection. It is therefore contemplated in the instant invention that nucleic acid molecules encoding Kunitz-type serine protease inhibitors such as Bikunin, Aprotinin or variants
30 and fragments thereof may be similarly administered to lung airways by any suitable gene therapy method as a means for stimulating the rate of mucociliary clearance of mucus and sputum in a subject in need of such treatment.

Searching Human Sequence Data

35 The existence of a distinct human protein homologous in function to aprotinin, was deduced following a unique analysis of sequence entries to the expressed-sequence-tag data-base (hereafter termed dbEST) at the NCBI

(National Center for Biological Information, Maryland). Using the TBlastN algorithm (BLAST, or Basic Local Alignment Search Tool uses the method of Altschul et al., (1990) J. Mol Biol 215, 403-410, to search for similarities between a query sequence and all the sequences in a data-base, protein or nucleic acid in any combination), the data-base was examined for nucleotide sequences bearing homology to the sequence of bovine pre-pro-aprotinin, Trasylol®. This search of numerous clones was selectively narrowed to two particular clones which could possibly encode for a deduced amino acid sequence that would correspond to a human protein homologous in function to aprotinin. The selected nucleic acid sequences were R35464 (SEQ ID NO: 12) and R74593 (SEQ ID NO: 14) that were generated from a human placental nucleic acid library. The translated protein sequence in the longest open reading frame for R35464 (SEQ ID NO: 13) was missing one of the 6 cysteines that are critical for formation of the Kunitz-domain covalent structure, meaning that the nucleic acid sequence of R35464 could not yield a functional inhibitor. Similarly, the longest translated open reading frame from clone R74593 (SEQ ID NO: 15) contained a stop codon 5' to the region encoding the Kunitz like sequence, meaning that this sequence, could not be translated to yield a functional secreted Kunitz domain. The significance of these sequences alone was unclear. It was possible that they represented a) the products of pseudogenes, b) regions of untranslated mRNA, or c) the products of viable mRNA which had been sequenced incorrectly.

Discovery of Human Bikunin

To specifically isolate and determine the actual human sequence, cDNA primers were designed to be capable of hybridizing to sequences located 5' and 3' to the segment of cDNA encoding our proposed Kunitz like sequences found within R35464 and R74593. The primers used to amplify a fragment encoding the Kunitz like sequence of R74593 were CGAAGCTTCATCTCCGAAGCTCCAGACG (the 3' primer with a HindIII site; SEQ ID NO.:33) and AGGATCTAGACAATAATTACCTGACCAAGGA (the 5' primer with an XbaI site; SEQ ID NO.:34).

These primers were used to amplify by PCR (30 cycles) a 500 base pair product from a human placental cDNA library from Clontech (MATCHMAKER, Cat #HL4003AB, Clontech Laboratories, Palo Alto, CA), which was subcloned into Bluescript-SK+ and sequenced with the T3 primer with a Sequenase™ kit version 2.0. Surprisingly, the sequence of the fragment obtained using our primers was different from the sequence listed in the dbEST data base for clone

R74593. In particular, our new sequence contained an additional guanosine base inserted 3' to the putative stop codon, but 5' to the segment encoding the Kunitz-like sequence (Figure 3). The insertion of an additional G shifted the stop codon out of the reading frame for the Kunitz-like domain (G at base pair 114 of the corrected sequence for R74593; Figure 3).

Subsequent query of the dbEST for sequences homologous to the Kunitz-like peptide sequence of R74593 yielded H94519 derived from human retina library and N39798. These sequences contained a Kunitz-like sequence that was almost identical to the Kunitz-like domain encoded in R35464 except that it contained all six of the characteristic cysteines. Overlay of each of the nucleotide sequences with that of R74593 (corrected by the insertion of G at b,p, 114) and R35464 was used to obtain a consensus nucleotide sequence for a partial human placental bikunin (SEQ ID NO.: 9; Figure 3). The translated consensus sequence yielded an open reading frame extending from residue -18 to +179 (Figure 3; full translation SEQ ID NO.: 10) that contained two complete Kunitz-like domain sequences, within the region of amino acid residues 17-64 and 102-159 respectively.

Further efforts attempted to obtain additional 5' sequence by querying dbEST with the sequence of R35464. Possible matches from such searches, that possessed additional 5' sequence were then in turn used to re-query the dbEST. In such an iterative fashion, a series of overlapping 5' sequences were identified which included clones H16866, T66058, R34808, R87894, N40851 and N39876 (Figure 4). Alignment of some of these sequences suggested the presence of a 5' ATG which might serve as a start site for synthesis of the consensus translated protein sequence. From this selected information, it was now possible to selectively screen for, and determine the nucleic acid and polypeptide sequences of a human protein with homologous function to aprotinin.

Re-interrogation of the dbEST revealed a number of new EST entries shown schematically in Figure 4B. Overlap with these additional ESTs allowed us to construct a much longer consensus oligonucleotide sequence (Figure 4C) that extended both 5' and 3' beyond the original oligonucleotide sequence depicted in Figure 3. In fact, the new sequence of total length 1.6 kilobases extended all the way to the 3' poly-A tail. The increased number of overlapping ESTs at each base-pair position along the sequence improved the level of confidence in certain regions such as the sequence overlapping with the 3' end of EST R74593 (Figure 3). Several overlapping ESTs in this region corroborated two critical base deletions relative to R74593 (located as bold underlined in Figure

4C, map positions 994 and 1005). Translation of the new consensus sequence (Figure 4D) in the bikunin encoding frame yielded a form of placental bikunin that was larger (248 amino acids) than the mature sequence (179 amino acids) encoded from the original consensus (SEQ ID NO.: 1), and was terminated by an in-frame stop codon within the oligonucleotide consensus. The size increase was due to a frame shift in the 3' coding region resulting from removal of the two base insertions unique to EST R74593. The frame shift moved the stop codon of the original consensus (Figure 3) out of frame enabling read through into a new frame encoding the additional amino acid sequence. The new translation product (Figure 4D) was identical to the original protein consensus sequence (SEQ ID NO.: 1) between residues +1 to +175 (encoding the Kunitz domains), but contained a new C-terminal extension exhibiting a putative 24 residue long transmembrane domain (underlined in Figure 4D) followed by a short 31 residue cytoplasmic domain. The precise sequence around the initiator methionine and signal peptide was somewhat tentative due to considerable heterogeneity amongst the overlapping ESTs in this region.

Analysis of the protein sequence by Geneworks™, highlighted asparagine residues at positions 30 and 67 as consensus sites for putative N-linked glycosylation. Asparagine 30 was not observed during N-terminal sequencing of the full length protein isolated from human placenta, consistent with it being glycosylated.

Cloning of Human Bikunin

The existence of a human mRNA corresponding to the putative human bikunin nucleotide sequence inferred from the analysis of Figure 3, was confirmed as follows. The nucleic acid primer hybridizing 5' to the Kunitz-encoding cDNA sequence of R35464 (b.p. 3-27 of consensus nucleotide sequence in Figure 3): GGTCTAGAGGCCGGGTCGTTTCTCGCCTGGCTGGGA (a 5' primer derived from R35464 sequence with an XbaI site; SEQ ID NO.: 35), and the nucleic acid primer hybridizing 3' to the Kunitz encoding sequence of R74593 (b.p. 680-700 of consensus nucleotide sequence in Figure 3), was used to PCR amplify, from a Clontech human placental library, a fragment of the size (ca. 670 b.p) expected from a cDNA consensus nucleotide sequence encoding the placental bikunin sequence of Figure 3 (Shown schematically in Figure 4A).

Using a 5' primer hybridizing to a sequence in R87894 that is 126 b.p 5' to the putative ATG start site discussed above, (shown schematically in Figure 4A at b.p. 110) plus the same 3' primer to R74593 as used above, it was possible to

amplify a fragment from a Clontech human placental library of the expected size (approximately 872 b.p) predicted by EST overlay (Shown schematically in Figure 4).

Sequencing of the 872 b.p. fragment showed it to contain nucleotide segment corresponding to b.p. 110 to 218 of EST R87894 at its 5' end and b.p. 310 to 542 of the consensus sequence for placental bikunin inferred from the EST overlay analysis (of Figure 3), at its 3' end. This 3' nucleotide sequence contained all of the Kunitz-like domain encoded by placental bikunin (102-159).

To obtain a cDNA encoding the entire extracellular region of the protein, the following 5' PCR primer: CACCTGATCGCGAGACCCC (SEQ ID NO.: 36) designed to hybridize to a sequence within EST R34808 was used with the same 3' primer to EST 74593 to amplify (30 cycles) an approximately 780 base-pair cDNA product from the human placental cDNA library. This product was gel purified, and cloned into the TA vector (Invitrogen) for DNA sequencing by the dideoxy method (Sanger F., et al., (1977) Proc. Natl. Acad. Sci (USA), 74, pp 5463-5467) with the following primers:

Vector Specific: GATTTAGGTGACACTATAG (SP6) (SEQ ID NO.: 37)
TAATACGACTCACTATAGGG (T7) (SEQ ID NO.: 38)

Gene Specific: TTACCTGACCAAGGAGGAGTGC (SEQ ID NO.: 39)
AATCCGCTGCATTCTGCTGGTG (SEQ ID NO.: 40)
CAGTCACTGGGCCTTGCCGT (SEQ ID NO.: 41)

The resulting cDNA sequence is depicted in Figure 4E together with its translation product. At the nucleotide level, the sequence exhibited only minor differences from the consensus EST sequence (Figure 4D). Translation of the sequence yielded a coding sequence containing an in-frame initiator ATG site, signal peptide and mature placental bikunin sequence and transmembrane domain. The translated sequence of the PCR product was missing the last 12 amino acid residues from the cytoplasmic domain as a consequence of the choice of selection of the 3' primer for PCR amplification. This choice of 3' PCR primer (designed based on the sequence of R74593) was also responsible for the introduction of an artifactual S to F mutation at amino acid position 211 of the translated PCR-derived sequence. The signal peptide deduced from translation of the PCR fragment was somewhat different to that of the EST consensus.

To obtain a full length placental bikunin cDNA, the PCR derived product

(Figure 4E) was gel purified and used to isolate a non-PCR based full length clone representing the bikunin sequence. The PCR derived cDNA sequence was labeled with ^{32}P -CTP by High Prime (Boehringer Mannheim) and used to probe a placental cDNA Library (Stratagene, UnizapTM λ library) using colony hybridization techniques. Approximately 2×10^6 phage plaques underwent 3 rounds of screening and plaque purification. Two clones were deemed full length (~1.5 kilobases) as determined by restriction enzyme analysis and based on comparison with the size of the EST consensus sequence (see above).

Sequencing of one of these clone by the dideoxy method yielded the oligonucleotide sequence depicted in Figure 4F. The translation product from this sequence yielded a protein with inframe initiator methionine, signal peptide and mature placental bikunin sequence. The mature placental bikunin sequence was identical to the sequence of the mature protein derived by translation of the EST consensus although the signal peptide sequence lengths and sequences differed. Unlike the PCR derived product, the cDNA derived by colony hybridization contained the entire ectodomain, transmembrane domain, cytoplasmic domain and in-frame stop codon. In fact, the clone extended all the way to the poly-A tail. The initiator methionine was followed by a hydrophobic signal peptide which was identical to the signal peptide encoded in the PCR derived clone. Subsequently we expressed and purified a soluble fragment of placental bikunin, bikunin (1-170), from Sf9 cells (Example 9), and found it to be a functional protease inhibitor (Example 10). Furthermore, we isolated from human placenta a soluble fragment of placental bikunin which was also an active protease inhibitor (Example 7).

Based on the above observations, it seems that full length placental bikunin has the capacity to exist as a transmembrane protein on the surface of cells as well as a soluble protein. Other transmembrane proteins that contain Kunitz domains are known to undergo proteolytic processing to yield mixtures of soluble and membrane associated forms. These include two forms of the Amyloid Precursor Protein termed APP751 (Esch F., et al., (1990) *Science*, **248**, pp 1122-1124) and APP 770 (Wang R., et al., (1991), *J. Biol Chem*, **266**, pp16960-16964).

Contact activation is a process which is activated by exposure of damaged vascular surfaces to components of the coagulation cascade. Angiogenesis is a process that involves local activation of plasmin at endothelial surfaces. The specificity of placental bikunin and its putative capacity to anchor to cell surfaces, suggest that the physiologic functions of transmembranous placental

IHDFCLVSKVV GRCRASMPRW WYNVTDGSCQ LFVYGGCDGN SNNYLTKEEC LKKCATV

Bikunin (102-159) (SEQ ID NO.: 6)

YEEYCTANAVT GPCRASFPRW YFDVERNSCN NFIYGGCRGN KNSYRSEEC MLRCFRQ

5

Tissue factor pathway inhibitor precursor 1 (SEQ ID NO.: 18)

-HSFCAFKADD GPCKAIMKRF FFNIFTRQCE EFIYGGCEGN QNRFESLEEC KKMCTRD

10 Tissue factor pathway inhibitor precursor 1 (SEQ ID NO.: 19)

-PDFCFLEEDP GICRGYITRY FYNNQTKQCE RFKYGGCLGN MNNFETLEEC KNICEDG

Tissue factor pathway inhibitor precursor (SEQ ID NO.: 20)

-PSWCLTPADR GLCRANENRF YYNSVIGKCR PFKYSGCGGN ENNFTSKQEC LRACKKG

15

Tissue factor pathway inhibitor precursor 2 (SEQ ID NO.: 21)

-AEICLLPLDY GPCRALLLRY YYRYRTQSCR QFLYGGCEGN ANNFYTWEAC DDACWRI

Tissue factor pathway inhibitor precursor 2 (SEQ ID NO.: 22)

20 -PSFCYSPKDE GLCSANVTRY YFNPRYRTCD AFTYTGCGGN DNNFVSREDC KRACAKA

Amyloid precursor protein homologue (SEQ ID NO: 23)

-KAVCSQEAMT GPCRAVMPRT TFDLSKGKCV RFITGCGGN RNNFESEDYC MAVCKAM

25 Aprotinin (SEQ ID NO: 24)

RPDFCLEPPYT GPCKARIIRY FYNAKAGLCQ TFVYGGCRAK RNNFKSAEDC MRTCGGA

Inter- α -trypsin inhibitor precursor (SEQ ID NOs: 25)

----CQLGYSA GPCMGMTSRY FYNGTSMACE TFQYGGCMGN GNNFVTEKEC LQTC

30

Inter- α -trypsin inhibitor precursor (SEQ ID NOs: 26)VAACNLPIVR GPCRAFIQLW

AFDAVKGKCV LFPYGGCQGN GNKFYSEKEC REYCGVP

Amyloid precursor protein (SEQ ID NO: 27)

35 -EVCCSEQAET GPCRAMISRW YFDVTEGKCA PFFYGGCGGN RNNFDTEEYC MAVCGSA

Collagen α -3(VI) precursor (SEQ ID NO: 28)

----CKLPKDE GTCRDFILKW YYDPNTKSCA RFWYGGCGGN ENKFGSQKEC EKVC

HKI-B9 (SEQ ID NO: 29)

-PNVCAFPMEK GPCQTYMTRW FFFNFETGECE LFAYGGCGGN SNNFLRKEKC EKFCCKFT

5 The placental bikunin, isolated domains or other variants of the present invention may be produced by standard solid phase peptide synthesis using either t-Boc chemistry as described by Merrifield R.B. and Barany G., in: The peptides, Analysis, Synthesis, Biology, 2, Gross E. et al., Eds. Academic Press (1980) Chapter 1; or using F-moc chemistry as described by Carpino L.A., and Han G.Y., (1970) J. Amer Chem Soc., 92, 5748-5749, and illustrated in Example 2. 10 Alternatively, expression of a DNA encoding the placental bikunin variant may be used to produce recombinant placental bikunin variants.

The instant invention provides for the use of a purified human serine protease inhibitor which can specifically inhibit kallikrein, that has been isolated 15 from human placental tissue via affinity chromatography. The human serine protein inhibitor, herein called human placental bikunin, contains two serine protease inhibitor domains of the Kunitz class. In one particular embodiment, the instant invention embodies a protein having the amino acid sequence:

20 ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
25 ACMLRCFRQQ ENPPLPLGSK VVVLGAVS 179

(SEQ ID NO.: 1)

30 In a preferred embodiment the instant invention provides for native human placental bikunin protein having the amino acid sequence:

 ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
35 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 ACMLRCFRQQ ENPPLPLGSK 170

(SEQ ID NO.: 52)

In one aspect, the biological activity of the protein useful in practicing the instant invention is that it can bind to and substantially inhibit the biological

activity of trypsin, human plasma and tissue kallikreins, human plasmin and Factor XIIa. In a preferred embodiment, the present invention provides for a native human placental bikunin protein, in glycosylated form. In a further embodiment the instant invention encompasses native human bikunin protein which has been formed such that it contains at least one cysteine-cysteine disulfide bond. In a preferred embodiment, the protein contains at least one intra-chain cysteine-cysteine disulfide bond formed between a pair of cysteines selected from the group consisting of CYS11-CYS61, CYS20-CYS44, CYS36-CYS57, CYS106-CYS156, CYS115-CYS139, and CYS131-CYS152, wherein the cysteines are numbered according to the amino acid sequence of native human placental bikunin. One of ordinary skill will recognize that the protein of the instant invention may fold into the proper three-dimensional conformation, such that the biological activity of native human bikunin is maintained, where none, one or more, or all of the native intra-chain cysteine-cysteine disulfide bonds are present. In a most preferred embodiment, the protein of the instant invention is properly folded and is formed with all of the proper native cysteine-cysteine disulfide bonds.

Active protein for use in the instant invention can be obtained by purification from human tissue, such as placenta, or via synthetic protein chemistry techniques, as illustrated by the Examples below. It is also understood that the protein for use in the instant invention may be obtained using molecular biology techniques, where self-replicating vectors are capable of expressing the protein of the instant invention from transformed cells. Such protein can be made as non-secreted, or secreted forms from transformed cells. In order to facilitate secretion from transformed cells, to enhance the functional stability of the translated protein, or to aid folding of the bikunin protein, certain signal peptide sequences may be added to the NH₂-terminal portion of the native human bikunin protein.

In one embodiment, the instant invention thus provides for the native human bikunin protein with at least a portion of the native signal peptide sequence intact. Thus one embodiment of the invention provides for native human bikunin with at least part of the signal peptide, having the amino acid sequence:

35	A G S F L	A W L G S	L L L S G	V L A		-1
	A D R E R	S I H D F	C L V S K	V V G R C	R A S M P	25
	R W W Y N	V T D G S	C Q L F V	Y G G C D	G N S N N	50
	Y L T K E	E C L K K	C A T V T	E N A T G	D L A T S	75
	R N A A D	S S V P S	A P R R Q	D S E D H	S S D M F	100
40	N Y E E Y	C T A N A	V T G P C	R A S F P	R W Y F D	125

V E R N S	C N N F I	Y G G C R	G N K N S	Y R S E E	150
A C M L R	C F R Q Q	E N P P L	P L G S K	V V V L A	175
G A V S					179

5 (SEQ ID NO.: 2)

In a preferred embodiment, the instant invention provides for the use of a native human placental bikunin protein with part of the leader sequence intact, having the amino acid sequence of SEQ ID NO.: 52 with an intact leader segment having the amino acid sequence:

MAQLCGL RRSRAFLALL GSLLLLSGVLA -1

(SEQ ID NO.: 53)

In another embodiment, the instant invention provides for the use of bikunin protein with part of the leader sequence intact, having the amino acid sequence of SEQ ID NO.: 52 with the intact leader segment having the amino acid sequence:

MLR AEADGVSRLL GSLLLLSGVLA -1

(SEQ ID NO.: 54)

In a preferred numbering system used herein the amino acid numbered +1 is assigned to the NH2-terminus of the amino acid sequence for native human placental bikunin. One will readily recognize that functional protein fragments can be derived from native human placental bikunin, which will maintain at least part of the biological activity of native human placental bikunin, and act as serine protease inhibitors.

In one embodiment, the protein for use in the method of the instant invention comprises a fragment of native human placental bikunin, which contains at least one functional Kunitz-like domain, having the amino acid sequence of native human placental bikunin amino acids 7-159, hereinafter called "bikunin (7-159)". Thus the instant invention embodies a method that employs a protein having the amino acid sequence:

I H D F	C L V S K	V V G R C	R A S M P	25	
R W W Y N	V T D G S	C Q L F V	Y G G C D	G N S N N	50
Y L T K E	E C L K K	C A T V T	E N A T G	D L A T S	75
R N A A D	S S V P S	A P R R Q	D S E D H	S S D M F	100
N Y E E Y	C T A N A	V T G P C	R A S F P	R W Y F D	125
V E R N S	C N N F I	Y G G C R	G N K N S	Y R S E E	150
A C M L R	C F R Q				159

(SEQ ID NO.: 3)

The instant invention also provides for a protein having the amino acid sequence of a Kunitz-like domain consisting of the amino acid sequence of native human placental bikunin amino acids 102-159, hereinafter called "bikunin (102-159)". Thus one embodiment the instant invention encompasses a protein which contains at least one Kunitz-like domain having the amino acid sequence:

Y E E Y C T A N A V T G P C R A S F P R W Y F D	125
V E R N S C N N F I Y G G C R G N K N S Y R S E E	150
A C M L R C F R Q	159

(SEQ ID NO.: 6)

where the amino acid numbering corresponds to that of the amino acid sequence of native human placental bikunin. Another form of this domain can be a Kunitz-like domain consisting of the amino acid sequence of native human placental bikunin amino acids 106-156, "bikunin (106-156)" having the amino acid sequence:

C T A N A V T G P C R A S F P R W Y F D	125
V E R N S C N N F I Y G G C R G N K N S Y R S E E	150
A C M L R C	156

(SEQ ID NO.: 7)

Thus one of ordinary skill will recognize that fragments of the native human bikunin protein can be made which will retain at least some of the native protein biological activity. Such fragments can also be combined in different orientations or multiple combinations to provide for alternative proteins which retain some of, the same, or more biological activity of the native human bikunin protein.

One will readily recognize that biologically active protein employed in the method of the instant invention may comprise one or more of the instant Kunitz-like domains in combination with additional Kunitz-like domains from other sources. Biologically active protein of the method of the instant invention may comprise one or more of the instant Kunitz-like domains in combination with additional protein domains from other sources with a variety of biological activities. The biological activity of the protein useful in practicing the instant invention can be combined with that of other known protein or proteins to provide for multifunctional fusion proteins having predictable biological

activity. Thus, in one embodiment, the method of instant invention encompasses the use of a protein which contains at least one amino acid sequence segment the same as, or functionally equivalent to the amino acid sequence of either SEQ ID NO.: 5 or SEQ ID NO.: 7.

5 An open reading frame which terminates at an early stop codon can still code for a functional protein. The instant invention encompasses such alternative termination, and in one embodiment provides for the use of a protein of the amino acid sequence:

10	A D R E R	S I H D F	C L V S K	V V G R C	R A S M P	25
	R W W Y N	V T D G S	C Q L F V	Y G G C D	G N S N N	50
	Y L T K E	E C L K K	C A T V T	E N A T G	D L A T S	75
	R N A A D	S S V P S	A P R R Q	D S		92

15 (SEQ ID NO.: 8)

In one embodiment, the instant invention provides for the use of substantially purified, or recombinantly produced native human bikunin protein with an intact segment of the leader sequence, and at least a portion of the native transmembrane region intact. Thus one embodiment of the invention provides for the use of native human bikunin, with an intact leader sequence, and with at least part of the transmembrane domain (underlined), having an amino acid sequence selected from:

25	EST	MLR	AEADGVSRL	GSLLLSGVLA	-1		
	PCR	MAQLCGL	RRSRAFLAL	GSLLLSGVLA	-1		
	λcDNA	MAQLCGL	RRSRAFLAL	GSLLLSGVLA	-1		
30	EST	ADRERSIHDF	CLVSKVVGRC	RASMPRWWYN	VTGSCQLFV	YGGCDGNSNN	50
	PCR	ADRERSIHDF	CLVSKVVGRC	RASMPRWWYN	VTGSCQLFV	YGGCDGNSNN	50
	λcDNA	ADRERSIHDF	CLVSKVVGRC	RASMPRWWYN	VTGSCQLFV	YGGCDGNSNN	50
35	EST	YLTKEECLKK	CATVTENATG	DLATSRNAAD	SSVPSAPRRQ	DSEDHSSDMF	100
	PCR	YLTKEECLKK	CATVTENATG	DLATSRNAAD	SSVPSAPRRQ	DSEDHSSDMF	100
	λcDNA	YLTKEECLKK	CATVTENATG	DLATSRNAAD	SSVPSAPRRQ	DSEDHSSDMF	100
40	EST	NYEEYCTANA	VTGPCRASFP	RWYFDVERNS	CNNFIYGGCR	GNKNSYRSEE	150
	PCR	NYEEYCTANA	VTGPCRASFP	RWYFDVERNS	CNNFIYGGCR	GNKNSYRSEE	150
	λcDNA	NYEEYCTANA	VTGPCRASFP	RWYFDVERNS	CNNFIYGGCR	GNKNSYRSEE	150
45	EST	ACMLRCFRQQ	ENPPLPLGSK	<u>VVVLAGLFVM</u>	<u>VLILFLGASM</u>	<u>VYLIRVARRN</u>	200
	PCR	ACMLRCFRQQ	ENPPLPLGSK	<u>VVVLAGLFVM</u>	<u>VLILFLGASM</u>	<u>VYLIRVARRN</u>	200
	λcDNA	ACMLRCFRQQ	ENPPLPLGSK	<u>VVVLAGLFVM</u>	<u>VLILFLGASM</u>	<u>VYLIRVARRN</u>	200
	EST	QERALRTVWS	SGDDKEQLVK	NTYVL			225
	PCR	QERALRTVWS	FGD				213
	λcDNA	QERALRTVWS	SGDDKEQLVK	NTYVL			225

where EST is EST derived consensus SEQ ID NO.: 45, PCR is PCR clone SEQ ID

NO.:47, and λ cDNA is lambda cDNA clone SEQ ID NO.:49. In a preferred embodiment a protein of the method of the instant invention comprises one of the amino acid sequence of SEQ ID NO.: 45, 47 or 49 wherein the protein has been cleaved in the region between the end of the last Kunitz domain and the transmembrane region (underlined).

The instant invention also embodies the use of the protein wherein the signal peptide is deleted. Thus the method of the instant invention provides for a protein having the amino acid sequence of SEQ ID NO.: 52 continuous with a transmembrane amino acid sequence:

EST	<u>VVVLAGLFVM VLILFLGASM</u> VYLIRVARRN	200
EST	QERALRTVWS SGDDKEQLVK NTYVL	225

(SEQ ID NO.: 69)

a transmembrane amino acid sequence:

PCR	<u>VVVLAGLFVM VLILFLGASM</u> VYLIRVARRN	200
PCR	QERALRTVWS FGD	213

(SEQ ID NO.: 68)

or a transmembrane amino acid sequence:

λ cDNA	<u>VVVLAGLFVM VLILFLGASM</u> VYLIRVARRN	200
λ cDNA	QERALRTVWS SGDDKEQLVK NTYVL	225

(SEQ ID NO.: 67).

The protein amino acid sequences for use in the instant invention clearly teach one skilled in the art the appropriate nucleic acid sequences which can be used in molecular biology techniques to produce the proteins for use in the instant invention. Thus, one embodiment of the instant invention provides for use of a nucleic acid sequence which encodes for a human bikunin having the consensus DNA sequence of Figure 3 (SEQ ID NO.: 9), which translates into the amino acid sequence for native human placental bikunin sequence of Figure 3 (SEQ ID NO.: 10). In another embodiment, the instant invention provides for a consensus nucleic acid sequence of Figure 4C (SEQ ID NO.: 51) which encodes for an amino acid sequence of Figure 4D (SEQ ID NO.: 45).

In a preferred embodiment, the instant invention provides for the use of a nucleic acid sequence which encodes for native human placental bikunin having the DNA sequence of Figure 4F (SEQ ID NO.: 48) which encodes for the protein sequence of SEQ ID NO.: 49. In an another embodiment, the instant invention provides for a nucleic acid sequence of Figure 4E (SEQ ID NO.: 46) which

encodes for a protein sequence of SEQ ID NO.: 47.

One can easily recognize that certain allelic mutations, and conservative substitutions made in the nucleic acid sequence can be made which will still result in a protein amino acid sequence encompassed by the method of the instant invention. One of skill in the art can recognize that certain natural allelic mutations of the protein of the instant invention, and conservative substitutions of amino acids in the protein of the instant invention will not significantly alter the biological activity of the protein, and are encompassed by the instant invention.

The instant invention also provides for pharmaceutical compositions containing human placental bikunin and fragments thereof that are useful for stimulating MCC in patients impaired by mucociliary dysfunction.

The present invention also provides methods for stimulating MCC in a patient suffering from mucociliary dysfunction, wherein an effective amount of the disclosed human serine protease inhibitors of the present invention in a biologically compatible vehicle is administered to the patient.

The present invention also provides for a method for stimulating MCC that employs variants of placental bikunin, and the specific Kunitz domains described above, that contain amino acid substitutions that alter the protease specificity. Preferred sites of substitution are indicated below as positions Xaa¹ through Xaa³² in the amino acid sequence for native placental bikunin. Substitutions at Xaa¹ through Xaa¹⁶ are also preferred for variants of bikunin (7-64), while substitutions at Xaa¹⁷ through Xaa³² are preferred for variants of bikunin (102-159).

Thus the method of the present invention embodies the use of a protein having an amino acid sequence:

Ala Asp Arg Glu Arg Ser Ile Xaa ¹ Asp Phe	10
Cys Leu Val Ser Lys Val Xaa ² Gly Xaa ³ Cys	20
Xaa ⁴ Xaa ⁵ Xaa ⁶ Xaa ⁷ Xaa ⁸ Xaa ⁹ Trp Trp Tyr Asn	30
Val Thr Asp Gly Ser Cys Gln Leu Phe Xaa ¹⁰	40
Tyr Xaa ¹¹ Gly Cys Xaa ¹² Xaa ¹³ Xaa ¹⁴ Ser Asn Asn	50
Tyr Xaa ¹⁵ Thr Lys Glu Glu Cys Leu Lys Lys	60
Cys Ala Thr Xaa ¹⁶ Thr Glu Asn Ala Thr Gly	70
Asp Leu Ser Thr Ser Arg Asn Ala Ala Asp	80
Ser Ser Val Pro Ser Ala Pro Arg Arg Gln	90
Asp Ser Glu His Asp Ser Ser Asp Met Phe	100
Asn Tyr Xaa ¹⁷ Glu Tyr Cys Thr Ala Asn Ala	110

Val Xaa¹⁸ Gly Xaa¹⁹ Cys Xaa²⁰ Xaa²¹ Xaa²² Xaa²³ Xaa²⁴ 120
Xaa²⁵ Trp Tyr Phe Asp Val Glu Arg Asn Ser 130
Cys Asn Asn Phe Xaa²⁶ Tyr Xaa²⁷ Gly Cys Xaa²⁸ 140
Xaa²⁹ Xaa³⁰ Lys Asn Ser Tyr Xaa³¹ Ser Glu Glu 150
5 Ala Cys Met Leu Arg Cys Phe Arg Xaa³² Gln 160
Glu Asn Pro Pro Leu Pro Leu Gly Ser Lys 170
Val Val Val Leu Ala Gly Ala Val Ser 179
(SEQ ID NO: 11) .

10 where Xaa¹ - Xaa³² each independently represents a naturally occurring amino acid residue except Cys, with the proviso that at least one of the amino acid residues Xaa¹-Xaa³² is different from the corresponding amino acid residue of the native sequence.

In the present context, the term "naturally occurring amino acid residue" is intended to indicate any one of the 20 commonly occurring amino acids, i.e., Ala, Arg, Asn, Asp, Cys, Gln, Glu, Gly, His, Ile, Leu, Lys, Met, Phe, Pro, Ser, Thr, Trp, Tyr and Val.

By substituting one or more amino acids in one or more of the positions indicated above, it may be possible to change the inhibitor specificity profile of native placental bikunin or that of the individual Kunitz-like domains, bikunin(7-64) or bikunin (102-159) so that it preferentially inhibits other serine proteases such as, but not limited to, the enzymes of the complement cascade, TF/FVIIa, FXa, prostatic, thrombin, neutrophil elastase, cathepsin G or proteinase-3.

Examples of preferred variants of placental bikunin include those wherein Xaa¹ is an amino acid residue selected from the group consisting of His, Glu, Pro, Ala, Val or Lys, in particular wherein Xaa¹ is His or Pro; or wherein Xaa² is an amino acid residue selected from the group consisting of Val, Thr, Asp, Pro, Arg, Tyr, Glu, Ala, Lys, in particular wherein Xaa² is Val or Thr; or wherein Xaa³ is an amino acid residue selected from the group consisting of Arg, Pro, Ile, Leu, Thr, in particular wherein Xaa³ is Arg or Pro; or wherein Xaa⁴ is an amino acid residue selected from the group consisting of Arg, Lys and Ser, Gln, in particular wherein Xaa⁴ is Arg or Lys; or wherein Xaa⁵ is an amino acid residue selected from the group consisting of Ala, Gly, Asp, Thr, in particular wherein Xaa⁵ is Ala; or wherein Xaa⁶ is an amino acid residue selected from the group consisting of Ser, Ile, Tyr, Asn, Leu, Val, Arg, Phe, in particular wherein Xaa⁶ is Ser or Arg; or wherein Xaa⁷ is an amino acid residue selected from the group

5
10
15
20
25
30
35

Ile; or wherein Xaa²⁷ is an amino acid residue selected from the group consisting of Gly, Ser and Thr, in particular wherein Xaa²⁷ is Gly; or wherein Xaa²⁸ is an amino acid residue selected from the group consisting of Asp, Arg, Glu, Leu, Gly or Gln, in particular wherein Xaa²⁸ is Arg; or wherein Xaa²⁹ is an amino acid residue selected from the group consisting of Gly and Ala; or wherein Xaa³⁰ is an amino acid residue selected from the group consisting of Asn or Lys; or wherein Xaa³¹ is an amino acid residue selected from the group consisting of Gly, Asp, Leu, Arg, Glu, Thr, Tyr, Val, and Lys, in particular wherein Xaa³¹ is Arg or Lys; or wherein Xaa³² is an amino acid residue selected from the group consisting of Val, Gln, Asp, Gly, Ile, Ala, Met, and Thr, in particular wherein Xaa³² is Gln or Ala.

The invention also relates to DNA constructs that encode the Placental bikunin protein variants of the present invention. These constructs may be prepared by synthetic methods such as those described in Beaucage S.L. and Caruthers M.H., (1981) Tetrahedron Lett, 22, pp1859-1862; Matteucci M.D and Caruthers M.H., (1981), J. Am. Chem. Soc. 103, p 3185; or from genomic or cDNA which may have been obtained by screening genomic or cDNA libraries with cDNA probes designed to hybridize with placental bikunin encoding DNA sequence. Genomic or cDNA sequence can be modified at one or more sites to obtain cDNA encoding any of the amino acid substitutions or deletions described in this disclosure.

The instant invention also relates to expression vectors containing the DNA constructs encoding the placental bikunin, isolated domains or other variants of the present invention that can be used for the production of recombinant placental bikunin variants. The cDNA should be connected to a suitable promoter sequence which shows transcriptional activity in the host cell of choice, possess a suitable terminator and a poly-adenylation signal. The cDNA encoding the placental bikunin variant can be fused to a 5' signal peptide that will result in the protein encoded by the cDNA to undergo secretion. The signal peptide can be one that is recognized by the host organism. In the case of a mammalian host cell, the signal peptide can also be the natural signal peptide present in full length placental bikunin. The procedures used to prepare such vectors for expression of placental bikunin variants are well known in the art and are for example described in Sambrook et al., Molecular Cloning: A laboratory Manual, Cold Spring Harbor, New York, (1989).

The instant invention also relates to transformed cells containing the DNA constructs encoding the placental bikunin, isolated domains or other

variants of the present invention that can be used for the production of recombinant placental bikunin variants. A variety of combinations of expression vector and host organism exist which can be used for the production of the placental bikunin variants. Suitable host cells include baculovirus infected Sf9 insect cells, mammalian cells such as BHK, CHO, Hela and C-127, bacteria such as E. coli, and yeasts such as Saccharomyces cervisiae. Methods for the use of mammalian, insect and microbial expressions systems needed to achieve expression of placental bikunin are well known in the art and are described, for example, in Ausubel F.M et al., Current Protocols in Molecular Biology, John Wiley & Sons (1995), Chapter 16. For fragments of placental bikunin containing a single Kunitz inhibitor domain such as bikunin (7-64) and (102-159), yeast and E. coli expression systems are preferable, with yeast systems being most preferred. Typically, yeast expression would be carried out as described in US patent 5,164,482 for aprotinin variants and adapted in Example 5 of the present specification for placental bikunin (102-159). E.coli expression could be carried out using the methods described in US patent 5,032,573. Use of mammalian and yeast systems are most preferred for the expression of larger placental bikunin variants containing both inhibitor domains such as the variant bikunin(7-159).

DNA encoding variants of placental bikunin that possess amino acid substitution of the natural amino sequence can be prepared for expression of recombinant protein using the methods of Kunkel T.A., (1985) Proc. Natl. Acad. Sci USA 82, pp 488-492. Briefly, the DNA to be mutagenized is cloned into a single stranded bacteriophage vector such as M13. An oligonucleotide spanning the region to be changed and encoding the substitution is hybridized to the single stranded DNA and made double stranded by standard molecular biology techniques. This DNA is then transformed into an appropriate bacterial host and verified by dideoxynucleotide sequencing. The correct DNA is then cloned into the expression plasmid. Alternatively, the target DNA may be mutagenized by standard PCR techniques, sequenced, and inserted into the appropriate expression plasmid.

The following particular examples are offered by way of illustration, and not limitation, of certain aspects and preferred embodiments of the instant invention.

Example 1

Preparation of synthetic placental bikunin (102-159)

Materials and methods/Reagents used. The fluorogenic substrate Tos-

Gly-Pro-Lys-AMC was purchased from Bachem BioScience Inc (King of Prussia, PA). PNGB, Pro-Phe-Arg-AMC, Ala-Ala-Pro-Met-AMC, bovine trypsin (type III), human plasma kallikrein, and human plasmin were from Sigma (St. Louis, MO).

Recombinant aprotinin (Trasylol®) was from Bayer AG (Wuppertal, Germany). Pre-loaded Gln Wang resin was from Novabiochem (La Jolla, CA). Thioanisole, ethanedithiol and t-butyl methyl ether was from Aldrich (Milwaukee, WI).

Quantification of functional placental bikunin (7-64) and (102-159)

The amount of trypsin inhibitory activity present in the refolded sample at various stages of purification was measured using GPK-AMC as a substrate. Bovine trypsin (200 pmoles) was incubated for 5 min at 37°C with bikunin (7-64) or (102-159), from various stages of purification, in buffer A (50 mM Hepes, pH 7.5, 0.1 M NaCl, 2 mM CaCl₂ and 0.01% triton X-100). GPK-AMC was added (20 µM final) and the amount of coumarin produced was determined by measuring the fluorescence (ex = 370 nm, em = 432 nm) on a Perkin-Elmer LS-50B fluorimeter over a 2 min. period. For samples being tested the % inhibition for each was calculated according to equation 1; where R₀ is the rate of fluorescence increase in the presence of inhibitor and R₁ is the rate determined in the absence of added sample. One unit of activity for the inhibitor is defined as the amount needed to achieve 50% inhibition in the assay using the conditions as described.

$$\% \text{ inhibition} = 100 \times [1 - R_0/R_1] \quad (1)$$

Synthesis. Placental bikunin (102-159) was synthesized on an Applied Biosystems model 420A peptide synthesizer using NMP-HBTU Fmoc chemistry. The peptide was synthesized on pre loaded Gln resin with an 8-fold excess of amino acid for each coupling. Cleavage and deprotection was performed in 84.6% trifluoroacetic acid (TFA), 4.4% thioanisole, 2.2% ethanedithiol, 4.4% liquified phenol, and 4.4% H₂O for 2 hours at room temperature. The crude peptide was precipitated, centrifuged and washed twice in t-butyl methyl ether. The peptide was purified on a Dynamax 60A C18 reverse-phase HPLC column using a TFA/acetonitrile gradient. The final preparation (61.0 mg) yielded the correct amino acid composition and molecular mass by Electrospray mass spectroscopy (MH⁺ = 6836.1; calcd = 6835.5) for the predicted sequence:

YEEYCTANAV TGPCRASFP R WYFDVERN SC NNFIYGGCRG NKNSYRSEEA
CMLRCFRQ (SEQ ID NO.: 6)

5 **Purification.** Refolding of placental bikunin (102-159) was performed
according to the method of Tam et al., (J. Am. Chem. Soc. 1991, 113; 6657-62). A
portion of the purified peptide (15.2 mg) was dissolved in 4.0 ml of 0.1 M Tris,
pH 6.0, and 8 M urea. Oxidation of the disulfides was accomplished by
dropwise addition of a solution containing 23% DMSO, and 0.1 M Tris, pH 6.0
10 to obtain a final concentration of 0.5 mg/ml peptide in 20% DMSO, 0.1 M Tris,
pH 6.0, and 1 M urea. The solution was allowed to stir for 24 hr at 25°C after
which it was diluted 1:10 in buffer containing 50 mM Tris, pH 8.0, and 0.1 M
NaCl. The material was purified using a kallikrein affinity column made by
covalently attaching 30 mg of bovine pancreatic kallikrein (Bayer AG) to 3.5 mls
15 of CNBr activated Sepharose (Pharmacia) according to the manufacturers
instructions. The refolded material was loaded onto the affinity column at a
flow rate of 1 ml/min and washed with 50 mM Tris, pH 8.0, and 0.1 M NaCl
until absorbance at 280 nm of the wash could no longer be detected. The column
was eluted with 3 volumes each of 0.2 M acetic acid, pH 4.0 and 1.7. Active
20 fractions were pooled (see below) and the pH of the solution adjusted to 2.5. The
material was directly applied to a Vydac C18 reverse-phase column (5 micron,
0.46 x 25 cm) which had been equilibrated in 22.5% acetonitrile in 0.1% TFA.
Separation was achieved using a linear gradient of 22.5 to 40% acetonitrile in
0.1% TFA at 1.0 ml/min over 40 min. Active fractions were pooled, lyophilized,
25 redissolved in 0.1% TFA, and stored at -20°C until needed.

Results. Synthetic placental bikunin (102-159) was refolded using
20% DMSO as the oxidizing agent as described above, and purified by a 2-step
purification protocol as shown below, to yield an active trypsin inhibitor (Table
1 below).

Table 1 Purification table for the isolation of synthetic placental bikunin (102-159)

TABLE 1						
Purification Step	Vol (ml)	mg/ml	mg	Units ^c (U)	SpA (U/mg)	Yield
8.0 M Urea	4.0	3.75 ^a	15.0	0	0	-
20% DMSO	32.0	0.47 ^a	15.0	16,162	1,078	100
Kallikrein affinity	9.8	0.009 ^b	0.09	15,700	170,000	97
C18	3.0	0.013 ^{ab}	0.04	11,964	300,000	74

^aProtein determined by AAA.

^bProtein determined by OD280 nm using the extinction coefficient determined for the purified protein ($1.7 \times 10^4 \text{ Lmol}^{-1} \text{ cm}^{-1}$).

^cOne Unit is defined as the amount of material required to inhibit 50% of trypsin activity in a standard assay.

Chromatography of the crude refolded material over an immobilized bovine pancreatic kallikrein column selectively isolated 6.0% of the protein and 97% of the trypsin inhibitory activity present. Subsequent chromatography using C18 reverse-phase yielded a further purification of 2-fold, with an overall recovery of 74%. On RPHPLC, the reduced and refolded placental bikunin (102-159), exhibited elution times of 26.3 and 20.1 minutes, respectively. Mass spectroscopy analysis of the purified material revealed a molecular mass of 6829.8; a loss of 6 mass units from the starting material. This demonstrates the complete formation of the 3 disulfides predicted from the peptide sequence.

The isoelectric points of the purified, refolded synthetic placental bikunin (102-159) was determined using a Multiphor II Electrophoresis System (Pharmacia) run according to the manufacturers suggestions, together with pI standards, using a precast Ampholine[®] PAGplate (pH 3.5 to 9.5) and focused for 1.5 hrs. After staining, the migration distance from the cathodic edge of the gel to the different protein bands was measured. The pI of each unknown was determined by using a standard curve generated by a plot of the migration distance of standards versus the corresponding pI's. With this technique, the pI of placental bikunin (102-159) was determined to be 8.3, in agreement with the value predicted from the amino acid sequence. This is lower than the value of 10.5 established for the pI of aprotinin. (Tenstad et al., 1994, Acta Physiol. Scand. 152:33-50).

Example 2

Preparation of synthetic placental bikunin (7-64)

Placental bikunin (7-64) was synthesized, refolded and purified essentially as described for placental bikunin (102-159) but with the following modifications: during refolding, the synthetic peptide was stirred for 30 hr as a solution in 20% DMSO at 25°C; purification by C18 RP-HPLC was achieved with a linear gradient of 25 to 45% acetonitrile in 0.1% TFA over 40 min (1ml/min). Active fractions from the first C18 run were reapplied to the column and fractionated with a linear gradient (60 min, 1 ml/min) of 20 to 40% acetonitrile in 0.1% TFA.

Results. The final purified reduced peptide exhibited an $MH^+ = 6563$, consistent with the sequence:

IHDFCLVSKV VGRCRASMPR WWYNVTDGSC QLFVYGGCDG NSNNYLTKEE
CLKKCATV (SEQ ID NO. : 4)

The refolding and purification yielded a functional Kunitz domain that was active as an inhibitor of trypsin (Table 2 below).

Table 2A Purification table for the isolation of synthetic placental bikunin (7-64)

TABLE 2A						
Purification Step	Vol (ml)	mg/ml	mg	Units (U)	SpA (U/mg)	Yield
8.0 M Urea	8.0	2.5	20.0	0	0	-
20% DMSO	64.0	0.31	20.0	68,699	3,435	100
Kall affinity pH 4.0	11.7	0.10	1.16	43,333	36,110	62
Kall affinity pH 1.7	9.0	0.64	5.8	4972	857	7.2
C18-1	4.6	0.14	0.06	21,905	350,143	31.9
C18-2	1.0	0.08	0.02	7,937	466,882	11.5

The purified refolded protein exhibited an $MH^+ = 6558$, i.e. 5 ± 1 mass units less than for the reduced peptide. This demonstrates that refolding caused the formation of at least one appropriate disulfide bond.

The pI of placental bikunin (7-64) was determined using the methods employed to determine the pI of placental bikunin (102-159). Placental bikunin (7-64) exhibited a pI that was much higher than the predicted value (pI = 7.9).

Refolded placental bikunin (7-64) migrated to the cathodic edge of the gel (pH

9.5) and an accurate pI could not be determined under these conditions.

Continued Preparation of synthetic placental bikunin (7-64)

Because the synthetic placental bikunin (7-64) may not have undergone complete deprotection prior to purification and refolding, refolding was repeated using protein which was certain to be completely deprotected. Placental bikunin (7-64) was synthesized, refolded and purified essentially as described for placental bikunin (102-159) but with the following modifications: during refolding, the synthetic peptide (0.27 mg/ml) was stirred for 30 hr as a solution in 20% DMSO at 25 C; purification by C18 RP-HPLC was achieved with a linear gradient of 22.5 to 50% acetonitrile in 0.1% TFA over 40 min (1 ml/min).

Results. The final purified reduced peptide exhibited an $MH^+ = 6567.5$, consistent with the sequence:

IHDFCLVSKV VGRCRASMPRW WYNVTDGSC QLFVYGGCDG NSNNYLTKEE
CLKKCATV (SEQ ID NO.: 4)

The refolding and purification yielded a functional Kunitz domain that was as active as an inhibitor of trypsin (Table 2B below).

Table 2B Purification table for the isolation of synthetic placental bikunin (7-64)

TABLE 2B						
Purification Step	Vol (ml)	mg/ml	mg	Units (U)	SpA (U/mg)	Yield
8.0 M Urea	4.9	2.1	10.5	0	0	-
20% DMSO	39.0	0.27	10.5	236,000	22,500	100
Kallikrein Affinity (pH 2)	14.5	0.3	0.43	120,000	279,070	50.9
C18 Reverse-Phase	0.2	1.2	0.24	70,676	294,483	30.0

The purified refolded protein exhibited an $MH^+ = 6561.2$, i.e. 6.3 mass units less than for the reduced peptide. This demonstrates that refolding caused the formation of the expected three disulfide bonds.

The pI of refolded placental bikunin (7-64) was determined using the methods employed to determine the pI of placental bikunin (102-159). Refolded placental bikunin (7-64) exhibited a pI of 8.85, slightly higher than the predicted value (pI = 7.9).

Example 3

In vitro specificity of functional placental bikunin fragment (102-159)

Proteases. Bovine trypsin, human plasmin, and bovine pancreatic kallikrein quantitation was carried out by active site titration using p-nitrophenyl p'-guanidinobenzoate HCl as previously described (Chase, T., and Shaw, E., (1970) *Methods Enzymol.* 19, 20-27). Human kallikrein was quantitated by active site titration using bovine aprotinin as a standard and PFR-AMC as a substrate assuming a 1:1 complex formation. The K_m for GPK-AMC with trypsin and plasmin under the conditions used for each enzyme was 29 μ M and 726 μ M, respectively; the K_m for PFR-AMC with human plasma kallikrein and bovine pancreatic kallikrein was 457 μ M and 81.5 μ M, respectively; the K_m for AAPR-AMC with elastase was 1600 μ M. Human tissue kallikrein (Bayer, Germany) quantification was carried out by active site titration using p-nitrophenyl p'-guanidinobenzoate HCl as previously described (Chase, T., and Shaw, E., (1970) *Methods Enzymol.* 19, 20-27).

Inhibition Kinetics: The inhibition of trypsin by placental bikunin (102-159) or aprotinin was measured by the incubation of 50 pM trypsin with placental bikunin (102-159) (0-2 nM) or aprotinin (0-3 nM) in buffer A in a total volume of 1.0 ml. After 5 min. at 37°C, 15 μ l of 2 mM GPK-AMC was added and the change in fluorescence (as above) was monitored. The inhibition of human plasmin by placental bikunin (102-159) and aprotinin was determined with plasmin (50 pM) and placental bikunin (102-159) (0-10 nM) or aprotinin (0-4 nM) in buffer containing 50 mM Tris-HCl (pH 7.5), 0.1 M NaCl, and 0.02% triton x-100. After 5 min. incubation at 37°C, 25 μ l of 20 mM GPK-AMC was added and the change in fluorescence monitored. The inhibition of human plasma kallikrein by placental bikunin (102-159) or aprotinin was determined using kallikrein (2.5 nM) and placental bikunin (102-159) (0-3 nM) or aprotinin (0-45 nM) in 50 mM Tris-HCl (pH 8.0), 50 mM NaCl, and 0.02% triton x-100. After 5 min. at 37°C 15 μ l of 20 mM PFR-AMC was added and the change in fluorescence monitored. The inhibition of bovine pancreatic kallikrein by placental bikunin (102-159) and aprotinin was determined in a similar manner with kallikrein (92 pM), placental bikunin (102-159) (0-1.6 nM) and aprotinin (0-14 pM) and a final substrate concentration of 100 μ M. The apparent inhibition constant K_i^* was determined using the nonlinear regression data analysis program Enzfitter software (Biosoft, Cambridge, UK): The kinetic data from each experiment were analyzed in terms of the equation for a tight binding inhibitor:

$$V_i/V_o = 1 - (E_o + I_o + K_i^* - [(E_o + I_o + K_i^*)^2 - 4 E_o I_o]^{1/2}) / 2E_o \quad (2)$$

where V_i/V_o is the fractional enzyme activity (inhibited vs. uninhibited rate),
 5 and E_o and I_o are the total concentrations of enzyme and inhibitor, respectively.
 K_i values were obtained by correcting for the effect of substrate according to the
 equation:

$$K_i = K_i^* / (1 + [S_o]/K_m) \quad (3)$$

10 (Boudier, C., and Bieth, J. G., (1989) *Biochim Biophys Acta*. 995: 36-41)

For the inhibition of human neutrophil elastase by placental bikunin (102-
 159) and aprotinin, elastase (19 nM) was incubated with placental bikunin (102-
 159) (150 nM) or aprotinin (0-7.5 μ M) in buffer containing 0.1 M Tris-HCl (pH
 15 8.0), and 0.05% triton X-100. After 5 min at 37°C, AAPM-AMC (500 μ M or 1000
 μ M) was added and the fluorescence measured over a two-minute period. K_i
 values were determined from Dixon plots of the form $1/V$ versus $[I]$ performed
 at two different substrate concentrations (Dixon et al., 1979).

The inhibition of human tissue kallikrein by aprotinin, placental bikunin
 20 fragment (7-64) or placental bikunin fragment (102-159) was measured by the
 incubation of 0.35 nM human tissue kallikrein with placental bikunin (7-64) (0-40
 nM) or placental bikunin (102-159) (0-2.5 nM), or aprotinin (0-0.5 nM) in a 1 ml
 reaction volume containing 50 mM Tris-HCl buffer pH 9.0, 50 mM NaCl, and
 0.1% triton x-100. After 5 min. at 37°C, 5 μ l of 2 mM PFR-AMC was added
 25 achieving 10 μ M final and the change in fluorescence monitored. The K_m for
 PFR-AMC with human tissue kallikrein under the conditions employed was 5.7
 μ M. The inhibition of human factor Xa (American Diagnostica, Inc, Greenwich,
 CT) by synthetic placental bikunin (102-159), recombinant placental bikunin,
 and aprotinin was measured by the incubation of 0.87 nM human factor Xa with
 30 increasing amounts of inhibitor in buffer containing 20 mM Tris (pH 7.5), 0.1 M
 NaCl, and 0.1% BSA. After 5 min. at 37°C, 30 μ l of 20 mM LGR-AMC (Sigma)
 was added and the change in fluorescence monitored. The inhibition of human
 urokinase (Sigma) by Kunitz inhibitors was measured by the incubation of
 urokinase (2.7 ng) with inhibitor in a total volume of 1 ml buffer containing 50
 35 mM Tris-HCl (pH 8.0), 50 mM NaCl, and 0.1% Triton x-100. After 5 min. at
 37°C, 35 μ l of 20 mM GGR-AMC (Sigma) was added and the change in
 fluorescence monitored. The inhibition of Factor XIa (from Enzyme Research

Labs, Southbend, IN) was measured by incubating FXIa (0.1 nM) with either 0 to 800 nM placental bikunin (7-64), 0 to 140 nM placental bikunin (102-159) or 0 to 40 uM aprotinin in buffer containing 50 mM Hepes pH 7.5, 100 mM NaCl, 2 mM CaCl₂, 0.01% triton x-100, and 1% BSA in a total volume of 1 ml. After 5 min at 37 C, 10 ul of 40 mM Boc-Glu(OBzl)-Ala-Arg-AMC (Bachem Biosciences, King of Prussia, PA) was added and the change in fluorescence monitored.

Results: A direct comparison of the inhibition profiles of placental bikunin (102-159) and aprotinin was made by measuring their inhibition constants with various proteases under identical conditions. The K_i values are listed in Table 3 below.

Table 3 Ki values for the inhibition of various proteases by bikunin (102-159)

TABLE 3				
Protease (concentration)	bikunin (102-159) Ki (nM)	Aprotinin Ki (nM)	Substrate (concentration)	Km (mM)
Trypsin (48.5 pM)	0.4	0.8	GPK-AMC (0.03 mM)	0.022
Chymotrypsin (5 nM)	0.24	0.86	AAPF-pNA (0.08 mM)	0.027
Bovine Pancreatic Kallikrein (92.0 pM)	0.4	0.02	PFR-AMC (0.1 mM)	0.08
Human Plasma Kallikrein (2.5 nM)	0.3	19.0	PFR-AMC (0.3 mM)	0.46
Human Plasmin (50 pM)	1.8	1.3	GPK-AMC (0.5 mM)	0.73
Human Neutrophil Elastase (19 nM)	323.0	8500.0	AAPM-AMC (1.0 μM)	1.6
Factor XIIa	>300.0	12,000.0	PFR-AMC (0.2 μM)	0.35
Human Tissue Kallikrein (0.35 nM)	0.13	0.004	PFR-AMC (10 μM)	0.0057
factor Xa (0.87 nM)	274	N.I. at 3 μM	LGR-AMC (0.6 mM)	N.D.
urokinase	11000	4500	GGR-AMC (0.7 mM)	N.D.
factor XIa (0.1 nM)	15	288	E(OBz)AR-AMC (0.4 mM)	0.46

Placental bikunin (102-159) and aprotinin inhibit bovine trypsin and human plasmin to a comparable extent under the conditions employed. Aprotinin inhibited elastase with a K_i of 8.5 μM. Placental bikunin (102-159) inhibited elastase with a K_i of 323nM. The K_i value for the placental bikunin (102-159) inhibition of bovine pancreatic kallikrein was 20-fold higher than that of aprotinin inhibition. In contrast, placental bikunin (102-159) is a more potent inhibitor of human plasma kallikrein than aprotinin and binds with a 56-fold higher affinity.

Because placental bikunin (102-159) is greater than 50 times more potent than Trasylol® as an inhibitor of kallikrein, smaller amounts of human placental bikunin, or fragments thereof (i.e. placental bikunin (102-159)) are needed than Trasylol® in order to maintain the effective patient doses of inhibitor in KIU. This reduces the cost per dose of the drug and reduces the likelihood of adverse nephrotoxic effects upon re-exposure of the medicament to patients. Furthermore, the protein is human derived, and thus much less immunogenic in man than aprotinin which is derived from cows. This results in significant reductions in the risk of incurring adverse immunologic events upon re-exposure of the medicament to patients.

Example 4

In vitro specificity of functional placental bikunin fragment (7-64)

In vitro specificity of functional human placental bikunin (7-64) was determined using the materials and methods as described in the Examples above.

Results: The table below shows the efficacy of placental bikunin (7-64) as an inhibitor of various serine proteases *in vitro*. Data is shown compared against data obtained for screening inhibition using either placental bikunin (102-159), or aprotinin (Trasylol®).

Table 4 A Ki values for the inhibition of various proteases by bikunin(7-64)

TABLE 4A			
Protease (concentration)	bikunin(7-64) Ki (nM)	Aprotinin Ki (nM)	Bikunin (102-159) Ki (nM)
Trypsin (48.5 pM)	0.17	0.8	0.4
Bovine Pancreatic Kallikrein (92.0 pM)	0.4	0.02	0.4
Human Plasma Kallikrein (2.5 nM)	2.4	19.0	0.3
Human Plasmin (50 pM)	3.1	1.3	1.8
Bovine chymotrypsin (5 nM)	0.6	0.9	0.2
Factor XIIa	>300	12000	>300
elastase	>100	8500	323

The results show that the amino acid sequence encoding placental bikunin (7-64) can be refolded to obtain an active serine protease inhibitor that is effective against at least four trypsin-like serine proteases.

Table 4B below also shows the efficacy of refolded placental bikunin (7-64) as an inhibitor of various serine proteases *in vitro*. Refolded placental bikunin (7-64) was prepared from protein that was certain to be completely deprotected prior to purification and refolding. Data is shown compared against data obtained for screening inhibition using either placental bikunin (102-159), or aprotinin (Trasylol®).

Table 4B Ki values for the inhibition of various proteases by refolded bikunin (7-64)

TABLE 4B			
Protease (concentration)	bikunin (7-64) Ki (nM)	Aprotinin Ki (nM)	bikunin (102-159) Ki (nM)
Trypsin (50 pM)	0.2	0.8	0.3
Human Plasma Kallikrein (0.2 nM)	0.7	19.0	0.7
Human Plasmin (50 pM)	3.7	1.3	1.8
Factor XIIa	not done	12,000	4,500
Factor XIa (0.1 nM)	200	288	15
Human Tissue Kallikrein	2.3	0.004	0.13

Suprisingly, placental bikunin (7-64) was more potent than aprotinin at inhibiting human plasma kallikrein, and at least similar in efficacy as a plasmin inhibitor. These data show that placental bikunin (7-64) is at least as effective as aprotinin, using *in vitro* assays, and that one would expect better or similar potency *in vivo*.

Example 5

Expression of placental bikunin variant (102-159) in yeast

The DNA sequence encoding placental bikunin 102-159 (SEQ ID NO.: 6) was generated using synthetic oligonucleotides. The final DNA product consisted (5' to 3') of 15 nucleotides from the yeast α -mating factor propeptide sequence fused to the in-frame cDNA sequence encoding placental bikunin (102-159), followed by an in-frame stop codon. Upon cloning into a yeast expression vector pS604, the cDNA would direct the expression of a fusion protein comprising an N-terminal yeast α -mating factor propeptide fused to the 58 amino acid sequence of placental bikunin (102-159). Processing of this fusion protein at a KEX-2 cleavage site at the junction between the α -mating factor and Kunitz domain was designed to liberate the Kunitz domain at its native N-terminus.

A 5' sense oligonucleotide of the following sequence and containing a HindIII site for cloning was synthesized:

GAA GGG GTA AGC TTG GAT AAA AGA TAT GAA GAA TAC TGC ACC GCC
AAC GCA GTC ACT GGG CCT TGC CGT GCA TCC TTC CCA CGC TGG TAC
TTT GAC GTG GAG AGG (SEQ ID NO.: 42)

A 3' antisense oligonucleotide of the following sequence and containing both a BamHI site for cloning and a stop codon was synthesized:

5 CGC GGA TCC CTA CTG GCG GAA GCA GCG GAG CAT GCA GGC CTC CTC
AGA GCG GTA GCT GTT CTT ATT GCC CCG GCA GCC TCC ATA GAT GAA
GTT ATT GCA GGA GTT CCT CTC CAC GTC AAA GTA CCA GCG
(SEQ ID NO. : 43)

10 The oligonucleotides were dissolved in 10 mM Tris buffer pH 8.0
containing 1 mM EDTA, and 12 ug of each oligo were added combined and
brought to 0.25M NaCl. To hybridize, the oligonucleotides were denatured by
boiling for 5 minutes and allowed to cool from 65°C to room temp over 2 hrs.
Overlaps were extended using the Klenow fragment and digested with HindIII
15 and BamHI. The resulting digested double stranded fragment was cloned into
pUC19 and sequence confirmed. A clone containing the fragment of the correct
sequence was digested with BamHI/HindIII to liberate the bikunin containing
fragment with the following + strand sequence:

20 GAA GGG GTA AGC TTG GAT AAA AGA TAT GAA GAA TAC TGC ACC GCC
AAC GCA GTC ACT GGG CCT TGC CGT GCA TCC TTC CCA CGC TGG TAC
TTT GAC GTG GAG AGG AAC TCC TGC AAT AAC TTC ATC TAT GGA GGC
TGC CGG GGC AAT AAG AAC AGC TAC CGC TCT GAG GAG GCC TGC ATG
CTC CGC TGC TTC CGC CAG TAG GGA TCC (SEQ ID. : 44)

25 which was then gel purified and ligated into BamHI/HindIII cut pS604. The
ligation mixture was extracted into phenol/chloroform and purified over a S-200
minispin column. The ligation product was directed transformed into yeast
strains SC101 and WHL341 and plated on ura selection plates. Twelve colonies
30 from each strain were re-streaked on ura drop out plates. A single colony was
inoculated into 2 ml of ura DO media and grown over night at 30°C. Cells were
pelleted for 2 minutes at 14000x g and the supernatants evaluated for their
content of placental bikunin (102-159).

35 *Detection of expression of placental bikunin (102-159) in transformed yeast*

Firstly, the supernatants (50 ul per assay) were evaluated for their
capacity to inhibit the *in vitro* activity of trypsin using the assay methods as
described in Example 1 (1 ml assay volume). An un-used media only sample as
well as a yeast clone expressing an inactive variant of aprotinin served as
40 negative controls. A yeast clone expressing natural aprotinin served as a positive

control and is shown for comparison.

The second method to quantify placental bikunin (102-159) expression exploited use of polyclonal antibodies (pAbs) against the synthetic peptide to monitor the accumulation of the recombinant peptide using Western blots. These studies were performed only with recombinants derived from strain SC101, since these produced greater inhibitory activity than recombinants derived from strain WHL341.

To produce the pAb, two 6-8 week old New Zealand White female rabbits (Hazelton Research Labs, Denver, Pa) were immunized on day zero with 250 ug of purified reduced synthetic placental bikunin (102-159), in Complete Freund's adjuvant, followed by boosts on days 14, 35 and 56 and 77 each with 125 ug of the same antigen in Incomplete Freund's adjuvant. Antiserum used in the present studies was collected after the third boost by established procedures. Polyclonal antibodies were purified from the antiserum over protein A.

Colonies 2.4 and 2.5 from transformation of yeast SC101 (Figure 8) as well as an aprotinin control were grown overnight in 50 ml of ura DO media at 30°C. Cells were pelleted and the supernatant concentrated 100-fold using a Centriprep 3 (Amicon, Beverly, MA) concentrator. Samples of each (30 µl) were subjected to SDS-PAGE on 10-20% tricine buffered gels (Novex, San Diego, CA) using the manufacturers procedures. Duplicate gels were either developed with a silver stain kit (Integrated Separation Systems, Nantick, MA) or transferred to nitrocellulose and developed with the purified polyclonal antibody elicited to synthetic bikunin (102-159). Alkaline-phosphatase conjugated goat anti-rabbit antibody was used as the secondary antibody according to the manufacturer's directions (Kirkegaard and Perry, Gaithersburg, MD).

Purification of placental bikunin (102-159) from a transformed strain of SC101

Fermentation broth from a 1L culture of SC101 strain 2.4 was harvested by centrifugation (4,000 g x 30 min.) then applied to a 1.0 ml column of anhydrochymotrypsin-sepharose (Takara Biochemical Inc., CA), that was previously equilibrated with 50 mM Hepes buffer pH 7.5 containing 0.1M NaCl, 2 mM CaCl₂ and 0.01 % (v/v) triton X-100. The column was washed with the same buffer but containing 1.0 M NaCl until the A280nm declined to zero, whereupon the column was eluted with 0.1M formic acid pH 2.5. Eluted fractions were pooled and applied to a C18 column (Vydac, 5µm, 4.6 x 250 mm) previously equilibrated with 0.1 % TFA, and eluted with a 50 min. linear gradient of 20 to 80% acetonitrile in 0.1 % TFA. Fractions containing placental bikunin

(102-159) were pooled and re-chromatographed on C18 employing elution with a linear 22.5 to 50% acetonitrile gradient in 0.1% TFA.

Results. Figure 8 shows the percent trypsin activity inhibited by twelve colonies derived from the transformation of each of strains SC101 and WHL341. The results show that all twelve colonies of yeast strain SC101 transformed with the trypsin inhibitor placental bikunin (102-159) had the ability to produce a substantial amount of trypsin inhibitory activity compared to the negative controls both of which showed no ability to inhibit trypsin. The activity is therefore related to the expression of a specific inhibitor in the placental bikunin variant (102-159) transformed cells. The yeast WHL341 samples contained minimal trypsin inhibitory activity. This may be correlated to the slow growth observed with this strain under the conditions employed.

Figure 9 shows the SDS-PAGE and western analysis of the yeast SC101 supernatants. Silver stained SDS-PAGE of supernatants derived from recombinant yeasts 2.4 and 2.5 expressing placental bikunin (102-159) as well as from the yeast expressing aprotinin yielded a protein band running at approximated 6 kDa, corresponding to the size expected for each recombinant Kunitz inhibitor domain. Western analysis showed that the 6 kDa bands expressed by stains 2.4. and 2.5 reacted with the pAb elicited to placental bikunin (102-159). The same 6 kDa band in the aprotinin control did not react with the same antibody, demonstrating the specificity of the antibody for the placental bikunin variant (102-159).

The final preparation of placental bikunin C-terminal domain was highly pure by silver-stained SDS-PAGE (Figure 10). The overall recovery of broth-derived trypsin inhibitory activity in the final preparation was 31%. N-terminal sequencing of the purified inhibitor indicated that 40% of the protein is correctly processed to yield the correct N-terminus for placental bikunin (102-159) while about 60 % of the material contained a portion of the yeast α -mating factor. The purified material comprised an active serine protease inhibitor exhibiting an apparent K_i of 0.35 nM for the *in vitro* inhibition of plasma kallikrein.

In conclusion, the accumulation both of a protease inhibitor activity and a protein immunochemically related to synthetic bikunin (102-159) in fermentation broth as well as the isolation of placental bikunin (102-159) from one of the transformed lines provided proof of expression of placental bikunin in the recombinant yeast strains described herein, showing for the first time the utility of yeasts for the production of placental bikunin fragments.

Additional constructs were prepared in an effort to augment the expression level of the Kunitz domain contained within placental bikunin 102-159, as well as to increase the yield of protein with the correct N-terminus. We hypothesized that the N-terminal residues of placental bikunin 102-159 (YEEY--) may have presented a cleavage site that is only poorly recognized by the yeast KEX-2 protease that enzymically removes the yeast a-factor pro-region. Therefore, we prepared yeast expression constructs for the production of placental bikunin 103-159 (N-terminus of EEY...), 101-159 (N-terminus of NYEEY...) and 98-159 (DMFNYEEY..) in order to modify the P' subsites surrounding the KEX-2 cleavage site. To attempt to augment the levels of recombinant protein expression, we also used the yeast preferred codons rather than mammalian preferred codons in preparing some of the constructs described below. The constructs were essentially prepared as described above for placental bikunin 102-159 (defined as construct #1) but with the following modifications:

Construct #2 placental bikunin 103-159, yeast codon usage
A 5' sense oligonucleotide

GAAGGGGTAA GCTTGGATAA AAGAGAAGAA TACTGTACTG CTAATGCTGT
TACTGGTCCA TGTAGAGCTT CTTTCCAAG ATGGTACTTT GATGTTGAAA GA
(SEQ ID NO.: 55)

and 3' antisense oligonucleotide

ACTGGATCCT CATTGGCGAA AACATCTCAA CATAAGGCT TCTTCAGATC
TGTAAGAATT TTTATTACCT CTACAACCAC CGTAAATAAA ATTATTACAA
GAATTTCTTT CAACATCAAA GTACCATCT (SEQ ID NO.: 56)

were manipulated as described for the production of an expression construct
(construct #1 above) for the expression of placental bikunin 102-159

Construct #3 placental bikunin 101-159, yeast codon usage
A 5' sense oligonucleotide

GAAGGGGTAA GCTTGGATAA AAGAAATTAC GAAGAATACT GTACTGCTAA
TGCTGTTACT GGTCCATGTA GAGCTTCTTT TCCAAGATGG TACTTTGATG

TTGAAAGA (SEQ ID NO.: 57)

and the same 3' antisense oligonucleotide as used for construct #2, were manipulated as described for the production of an expression construct (construct #1 above) for the expression of placental bikunin 102-159.

Construct #4 placental bikunin 98-159, yeast codon usage
A 5' sense oligonucleotide

GAAGGGGTAA GCTTGGATAA AAGAGATATG TTTAATTACG AAGAATACTG
TACTGCTAAT GCTGTTACTG GTCCATGTAG AGCTTCTTTT CCAAGATGGT
ACTTTGATGT TGAAAGA (SEQ ID NO.: 58)

and the same 3' antisense oligonucleotide as used for construct #2, were manipulated as described for the production of an expression construct (construct #1 above).

Yeast strain SC101 (MAT α , ura 3-52, suc 2) was transformed with the plasmids containing each of the above cDNAs, and proteins were expressed using the methods that were described above for the production of placental bikunin 102-159 with human codon usage. Approximately 250 ml of each yeast culture was harvested, and the supernatant from centrifugation (15 min x 3000 RPM) separately subjected to purification over 1 ml columns of kallikrein-sepharose as described above. The relative amount of trypsin inhibitory activity in the applysate, the amount of purified protein recovered and the N-terminal sequence of the purified protein were determined and are listed below in Table 7.

Table 7 Relative production levels of different proteins containing the C-terminal Kunitz domain of placental bikunin

TABLE 7				
Construct	Relative conc. of inhibitor in aplysate	N-terminal sequencing amount sequence (pmol)		Comments
#2	103-159 none detected	none	none	no expression
#3	101-159 25 % inhibition	none	none	low expression
#4	98-159 93 % inhibition	910	DMFNYE-	good expression correct product
#1	102-159 82 % inhibition	480	AKEEGV-	expression of active
				incorrectly processed protein

The results show that placental bikunin fragments of different lengths that contain the C-terminal Kunitz domain show wide variation in capacity to express functional secreted protein. Constructs expressing fragments 101-159 and 103-159 yielded little or low enzymic activity in the supernatants prior to purification, and N-terminal sequencing of 0.05 ml aliquots of each purified fraction yielded undetectable amounts of inhibitor. On the other hand expression either of placental bikunin 102-159 or 98-159 yielded significant amounts of protease activity prior to purification. N-terminal sequencing however showed that the purified protein recovered from expression of 102-159 was once again largely incorrectly processed, exhibiting an N-terminus consistent with processing of the majority of the pre-protein at a site within the yeast α -mating factor pro-sequence. The purified protein recovered from expression of placental bikunin 98-159 however was processed entirely at the correct site to yield the correct N-terminus. Furthermore, nearly twice as much protein was recovered as compared to the recovery of placental bikunin 102-159. Placental bikunin 98-159 thus represents a preferred fragment length for the production of the C-terminal Kunitz domain of placental bikunin by the α -mating factor pre-pro sequence/ KEX-2 processing system of *S. cerevisiae*,

Example 6

Alternative procedure for yeast expression

The 58 amino acid peptide derived from the R74593 translation product can also be PCR amplified from either the R87894-R74593 PCR product cloned into the TA vector™ (Invitrogen, San Diego, CA) after DNA sequencing or from human placental cDNA. The amplified DNA product will consist of 19 nucleotides from the yeast α -mating factor leader sequence mated to the R74593 sequence which codes for the YEEY--CFRQ (58 residues) so as to make the translation product in frame, constructing an α -mating factor/Kunitz domain fusion protein. The protein sequence also contains a kex 2 cleavage which will liberate the Kunitz domain at its native N-terminus.

The 5' sense oligonucleotide which contains a HindIII site for cloning will contain the following sequence:

GCCAAGCTTG GATAAAAGAT ATGAAGAAT ACTGCACCGC CAACGCA
(SEQ ID NO.: 30)

The 3' antisense oligonucleotide contains a BamHI site for cloning as well as a stop codon and is of the following sequence:

GGGGATCCTC ACTGCTGGCG GAAGCAGCGG AGCAT (SEQ ID NO.: 31)

The full 206 nucleotide cDNA sequence to be cloned into the yeast expression vector is of the following sequence:

CCAAGCTTGG ATAAAAGATA TGAAGAATAC TGCACCGCCA ACGCAGTCAC
TGGGCCTTGC CGTGCATCCT TCCCACGCTG GTACTTTGAC GTGGAGAGGA
ACTCCTGCAA TAAC TTCATC TATGGAGGCT GCCGGGGCAA TAAGAACAGC
TACCGCTCTG AGGAGGCCTG CATGCTCCGC TGCTTCCGCC AGCAGTGAGG
ATCCCC (SEQ ID NO.: 32)

After PCR amplification, this DNA will be digested with HindIII, BamHI and cloned into the yeast expression vector pMT15 (see US patent 5,164,482, incorporated by reference in the entirety) also digested with HindIII and BamHI.

The resulting plasmid vector is used to transform yeast strain SC 106 using the methods described in US patent 5,164,482. The URA 3+ yeast transformants are isolated and cultivated under inducing conditions. The yield of recombinant Placental bikunin variants is determined according to the amount of trypsin

inhibitory activity that accumulated in the culture supernatants over time using the *in vitro* assay method described above. Fermentation broths are centrifuged at 9000 rpm for 30 minutes. The supernatant is then filtered through a 0.4 then a 0.2 μ m filter, diluted to a conductivity of 7.5 ms, and adjusted to pH 3 with citric acid. The sample is then batch absorbed onto 200 ml of S-sepharose fast flow (Pharmacia) in 50 mM sodium citrate pH 3 and stirred for 60 min. The gel is subsequently washed sequentially with 2 L of each of: 50 mM sodium citrate pH 3.0; 50 mM Tris-HCL pH 9.0; 20 mM HEPES pH 6.0. The washed gel is transferred into a suitable column and eluted with a linear gradient of 0 to 1 M sodium chloride in 20 mM HEPES pH 6.0. Eluted fractions containing *in vitro* trypsin inhibitory activity are then pooled and further purified either by a) chromatography over a column of immobilized anhydrotrypsin (essentially as described in Example 2); b) by chromatography over a column of immobilized bovine kallikrein; or c) a combination of conventional chromatographic steps including gel filtration and /or anion-exchange chromatography.

Example 7

Isolation and characterization of native human placental bikunin from placenta

Bikunin protein was purified to apparent homogeneity from whole frozen placenta (Analytical Biological Services, Inc, Wilmington, DE). The placenta (740 gm) was thawed to room temperature and cut into 0.5 to 1.0 cm pieces, placed on ice and washed with 600 ml PBS buffer. The wash was decanted and 240 ml of placenta pieces placed into a Waring blender. After adding 300 ml of buffer consisting of 0.1 M Tris (pH 8.0), and 0.1 M NaCl, the mixture was blended on high speed for 2 min, decanted into 750.0 ml centrifuge tubes, and placed on ice. This procedure was repeated until all material was processed. The combined slurry was centrifuged at 4500 x g for 60 minutes at 4°C. The supernatant was filtered through cheese cloth and the placental bikunin purified using a kallikrein affinity column made by covalently attaching 70 mg of bovine pancreatic kallikrein (Bayer AG) to 5.0 mls of CNBr activated Sepharose (Pharmacia) according to manufacturers instruction. The material was loaded onto the affinity column at a flow rate of 2.0 ml/min and washed with 0.1 M Tris (pH 8.0), 0.1 M NaCl until absorbance at 280 nm of the wash could no longer be detected. The column was further washed with 0.1 M Tris (pH 8.0), 0.5 M NaCl and then eluted with 3 volumes of 0.2 M acetic acid, pH 4.0. Fractions containing kallikrein and trypsin inhibitory (see below) activity were pooled, frozen, and lyophilized. Placental bikunin was further purified by gel-filtration

chromatography using a Superdex 75 10/30 (Pharmacia) column attached to a Beckman System Gold HPLC system. Briefly, the column was equilibrated in 0.1 M Tris, 0.15 M NaCl, and 0.1% Triton X-100 at a flow rate of 0.5 ml/min. The lyophilized sample was reconstituted in 1.0 ml of 0.1 M Tris, pH 8.0 and injected onto the gel-filtration column in 200 µl aliquots. Fractions were collected (0.5 ml) and assayed for trypsin and kallikrein inhibitory activity. Active fractions were pooled, and the pH of the solution adjusted to 2.5 by addition of TFA. The material was directly applied to a Vydac C18 reverse-phase column (5 micron, 0.46 x 25 cm) which had been equilibrated in 20% acetonitrile in 0.1 %TFA. Separation was achieved using a linear gradient of 20 to 80% acetonitrile in 0.1% TFA at 1.0 ml/min over 50 minutes after an initial 20 minute wash at 20% acetonitrile in 0.1% TFA. Fractions (1ml) were collected and assayed for trypsin and kallikrein inhibitory activity. Fractions containing inhibitory activity were concentrated using a speed-vac concentrator (Savant) and subjected to N-terminal sequence analysis.

Functional assays for Placental Bikunin:

Identification of functional placental bikunin was achieved by measuring its ability to inhibit bovine trypsin and human plasma kallikrein. Trypsin inhibitory activity was performed in assay buffer (50 mM Hepes, pH 7.5, 0.1 M NaCl, 2.0 mM CaCl₂, 0.1% Triton x-100) at room temperature in a 96-well microtiter plate (Perkin Elmer) using Gly-Pro-Lys-Aminomethylcoumarin as a substrate. The amount of coumarin produced by trypsin was determined by measuring the fluorescence (ex = 370 nm, em = 432 nm) on a Perkin-Elmer LS-50B fluorimeter equipped with a plate reader. Trypsin (23 µg in 100 µl buffer) was mixed with 20 µl of the sample to be tested and incubated for 10 minutes at 25°C. The reaction was started by the addition of 50 µl of the substrate GPK-AMC (33 µM final) in assay buffer. The fluorescence intensity was measured and the % inhibition for each fraction was determined by:

$$\% \text{ inhibition} = 100 \times [1 - F_0/F_1]$$

where F_0 is the fluorescence of the unknown and F_1 is the fluorescence of the trypsin only control. Kallikrein inhibitory activity of the fractions was similarly measured using 7.0 nM kallikrein in assay buffer (50 mM Tris, pH 8.0, 50 mM NaCl, 0.1% triton x-100) and 66.0 µM Pro-Phe-Arg-AMC as a substrate.

Determination of the *in vitro* specificity of placental bikunin

The *In vitro* specificity of native human placental bikunin was determined using the materials and methods as described in the preceding examples above. Placental bikunin was quantified by active site titration against a known concentration of trypsin using GPK-AMC as a substrate to monitor the fraction of unbound trypsin.

Protein Sequencing

The 1 ml fraction (C18-29 Delaria) was reduced to 300 ml in volume, on a Speed Vac, to reduce the amount of organic solvent. The sample was then loaded onto a Hewlett-Packard miniature biphasic reaction column, and washed with 1 ml of 2% trifluoroacetic acid. The sample was sequenced on a Hewlett-Packard Model G1005A protein sequencing system using Edman degradation. Version 3.0 sequencing methods and all reagents were supplied by Hewlett-Packard. Sequence was confirmed for 50 cycles.

Results. Placental Bikunin was purified to apparent homogeneity by sequential kallikrein affinity, gel-filtration, and reverse-phase chromatography (see purification table below):

Table 5 Purification table for native Placental Bikunin (1-179)

TABLE 5					
Step	Vol (ml)	OD 280 (/ml)	OD 280	Units ^a (U)	Units/OD 280
Placenta Supernatant	1800.0	41.7	75,060	3,000,000	40.0
Kallikrein Affinity pH 4.0	20.0	0.17	3.36	16,000	4,880
Kallikrein Affinity pH 1.7	10.2	0.45	4.56	12,000	2,630
Superdex 75	15.0	0.0085	0.13	3,191	24,546

^aOne Unit is defined as that amount which inhibits 50% of trypsin activity in a standard assay.

The majority of the kallikrein and trypsin inhibitory activity eluted from the kallikrein affinity column in the pH 4.0 elution. Subsequent gel-filtration chromatography (Figure 5) yielded a peak of kallikrein and trypsin inhibitory activity with a molecular weight range of 10 to 40 kDa as judged by a standard curve generated by running molecular weight standards under identical conditions. Reverse-phase C18 chromatography (Figure 6) yielded 4 peaks of

inhibitory activity with the most potent eluting at approximately 30 %
acetonitrile. The activity associated with the first peak to elute from C18 (fraction
29) exhibited an amino acid sequence starting with amino acid 1 of the predicted
amino acid sequence of placental bikunin (ADRER...; SEQ ID NO.: 1), and was
5 identical to the predicted sequence for 50 cycles of sequencing (underlined
amino acids in Figure 3). Cysteine residues within this sequence stretch were
silent as expected for sequencing of oxidized protein. The cysteine residues at
amino acid positions 11 and 20 of mature placental bikunin were later identified
from sequencing of the S-pyridylethylated protein whereupon PTH-
10 pyridylethyl-cysteine was recovered at cycles 11 and 20.

Interestingly, the asparagine at amino acid residue number 30 of the
sequence (Figure 3) was silent showing that this site is likely to be glycosylated.
Fraction 29 yielded one major sequence corresponding to that of placental
bikunin starting at residue #1 (27 pmol at cycle 1) plus a minor sequence (2
15 pmol) also derived from placental bikunin starting at residue 6 (SIHD...). This
shows that the final preparation sequenced in fraction 29 is highly pure, and
most likely responsible for the protease inhibitory activity associated with this
fraction (Figure 6).

Accordingly, the final preparation of placental bikunin from C18
20 chromatography was highly pure based on a silver-stained SDS-PAGE analysis
(Figure 7), where the protein migrated with an apparent Mr of 24 kDa on a 10 to
20 % acrylamide tricine gel (Novex, San Diego, CA) calibrated with the
following molecular weight markers: insulin (2.9 kDa); bovine trypsin inhibitor
(5.8 kDa); lysozyme (14.7 kDa); β -lactoglobulin (18.4 kDa); carbonic anhydrase
25 (29 kDa); and ovalbumin (43 kDa). The above size of placental bikunin on SDS-
PAGE is consistent with that predicted from the full length coding sequence
(Figure 4F).

As expected based on the N-terminal sequencing results described above, the
purified protein reacted with an antibody elicited to placental bikunin (7-64) to yield a
30 band with the same Mr (Figure 12A) as observed for the purified preparation
detected on gels by silver stain (Figure 7). However, when the same preparation was
reacted with an antibody elicited to synthetic placental bikunin (102-159), a band
corresponding to the full length protein was not observed. Rather, a fragment that co-
migrated with synthetic bikunin (102-159) of approximately 6 kDa was observed. The
35 simplest interpretation of these results is that the purified preparation had undergone
degradation subsequent to purification to yield an N-terminal fragment comprising
the N-terminal domain and a C-terminal fragment comprising the C-terminal

domain. Assuming that the fragment reactive against antiserum to placental bikunin (7-64) is devoid of the C-terminal end of the full length protein, the size (24 kDa) would suggest a high state of glycosylation.

Table 6. below shows the potency of *in vitro* inhibition of various serine proteases by placental bikunin. Data are compared with that obtained with aprotinin (Trasylol®).

Table 6 Ki values for the inhibition of various proteases by placental bikunin

TABLE 6		
Protease (concentration)	Placental Bikunin Ki (nM)	Aprotinin Ki (nM)
Trypsin (48.5 pM)	0.13	0.8
Human Plasmin (50 pM)	1.9	1.3

The results show that placental bikunin isolated from a natural source (human placenta) is a potent inhibitor of trypsin-like serine proteases.

Example 8

Expression pattern of placental bikunin amongst different human organs and tissues

A multiple tissue northern was purchased from Clontech which contained 2 µg of polyA+ RNA from human heart, brain, placenta, lung, liver, skeletal muscle, kidney, and pancreas. Two different cDNA probes were used: 1) a gel purified cDNA encoding placental bikunin (102-159); 2) the 780 base pair PCR-derived cDNA (Figure 4E) liberated from a TA clone by digestion with EcoRI and gel purified. Each probe was labeled using ³²P-dCTP and a random priming labeling kit from Boehringer Mannheim Biochemicals (Indiana), then used to hybridize to the multiple tissue northern according to the manufacturers specifications. Autoradiographs were generated using Biomax film with an 18 hr exposure time, and developed using a Umax Scanner and scanned using Adobe Photoshop.

Results. The pattern of tissue expression observed using a placental bikunin (102-159) probe (Figure 11A) or a larger probe containing both Kunitz domains of placental bikunin (Figure 11B) was essentially the same as might be expected. The placental bikunin mRNA was most abundant in pancreas and placenta. Significant levels were also observed in lung, brain and kidney, while lower

levels were observed in heart and liver, and the mRNA was undetectable in skeletal muscle. The transcript size was 1.95 kilobases in all cases, in close agreement with the predicted size of placental bikunin deduced both from EST overlay and cloning of full length cDNA described in preceding sections.

The broad tissue distribution of the mRNA shows that placental bikunin is broadly expressed. Since the protein also contains a leader sequence it would have ample exposure to the human immune system, requiring that it become recognized as a self protein. Additional evidence for a broad tissue distribution of placental bikunin mRNA expression was derived from the fact that some of the EST entries with homology to placental bikunin (Figure 4B) were derived from human adult and infant brain, and human retina, breast, ovary, olfactory epithelium, and placenta. It is concluded therefore that administration of the native human protein to human patients would be unlikely to elicit an immune response.

Interestingly, the expression pattern of placental bikunin is somewhat reminiscent of that for bovine aprotinin which is found in high levels in bovine lung and pancreas. To further elucidate the expression pattern of placental bikunin, RT-PCR of total RNA from the following human cells was determined: un-stimulated human umbilical vein endothelial cells (HUVECs), HK-2 (line derived from kidney proximal tubule), TF-1 (erythroleukemia line) and phorbol ester (PMA)-stimulated human peripheral blood leukocytes. The probes used:

CACCTGATCGCGAGACCCC (sense; SEQ ID NO.: 59);

CTGGCGGAAGCAGCGGAGCATGC (antisense; SEQ ID NO.: 60),

were designed to amplify a 600 b.p placental bikunin encoding cDNA fragment. Comparisons were normalized by inclusion of actin primers to amplify an 800 b.p. actin fragment. Whereas the 800 b.p fragment identified on agarose gels with ethidium bromide was of equal intensity in all lanes, the 600 b.p. placental bikunin fragment was absent from the HUVECs but present in significant amounts in each of the other cell lines. We conclude that placental bikunin is not expressed in at least some endothelial cells but is expressed in some leukocyte populations.

Example 9

Purification and properties of Placental Bikunin (1-170) highly purified from a

Baculovirus / Sf9 expression system

A large fragment of Placental bikunin containing both Kunitz domains (Placental Bikunin 1-170) was expressed in Sf9 cells as follows. Placental bikunin cDNA obtained by PCR (Figure 4E) and contained within a TA vector (see previous Examples) was liberated by digestion with HindIII and XbaI yielding a fragment flanked by a 5' XbaI site and 3' HindIII site. This fragment was gel purified and then cloned into the M13mp19 vector (New England Biolabs, Beverly, MA). In vitro mutagenesis (Kunkel T.A., (1985) Proc. Natl. Acad. Sci. USA, 82: 488-492) was used to generate a PstI site 3' to the XbaI site at the 5' end, but 5' to the sequence encoding the ATG start site, natural placental bikunin signal peptide and mature placental bikunin coding sequence. The oligonucleotide used for the mutagenesis had the sequence:

5' CGC GTC TCG GCT GAC CTG GCC CTG CAG ATG GCG CAC GTG TGC GGG 3'
(SEQ ID NO.: 61)

A stop codon (TAG) and BglII / XmaI site was similarly engineered at the 3' end of the cDNA using the oligonucleotide:

5' CTG CCC CTT GGC TCA AAG TAG GAA GAT CTT CCC CCC GGG GGG GTG
GTT CTG GCG GGG CTG 3' (SEQ ID NO.: 62).

The stop codon was in frame with the sequence encoding placental bikunin and caused termination immediately following the Lysine at amino acid residue 170, thus encoding a truncated placental bikunin fragment devoid of the putative transmembrane domain. The product from digestion with PstI and BglII was isolated and cloned into the BacPac8 vector for expression of Placental bikunin fragment (1-170) which contains both Kunitz domains but which is truncated immediately N-terminal to the putative transmembrane segment.

The expression of Bikunin by Sf-9 insect cells was optimal at a multiplicity of infection of 1 to 1 when the medium was harvested at 72 h post infection. After harvesting, the baculovirus cell culture supernatant (2L) was adjusted to pH 8.0 by the addition of Tris-HCl. Bikunin was purified by chromatography using a 5 ml bovine pancreatic kallikrein affinity column as previously described in Example 7 for the purification of native placental bikunin from placenta. Eluted material was adjusted to pH 2.5 with TFA and subjected to chromatography on a C18 reverse-phase column (1.0 x 25 cm) equilibrated in 10% acetonitrile in 0.1% TFA at a flow rate of 1 ml/min. The bikunin was eluted with a linear gradient of 10 to 80% acetonitrile

in 0.1% TFA over 40 min. Active fractions were pooled, lyophilized, redissolved in 50 mM Hepes (pH 7.5), 0.1 M NaCl, 2 mM CaCl₂, and 0.1% triton x-100, and stored at -20°C until needed. The concentration of recombinant bikunin was determined by amino acid analysis.

5

Results. Recombinant bikunin was purified from baculovirus cell culture supernatant using a 2-step purification protocol as shown below, to yield an active trypsin inhibitor (Table 8 below).

10 **Table 8 Purification of recombinant bikunin from transformed culture supernatant**

TABLE 8

Purification Step	Vol (ml)	OD 280/ml	OD 280 total	Units (U)	Specific activity (U/OD)
Supernatant	2300.0	9.0	20,700	6,150,000	297
Kallikrein affinity	23.0	0.12	2.76	40,700	14,746
C18 reverse-phase	0.4	3.84	1.54	11,111	72,150

Chromatography of the crude material over an immobilized bovine pancreatic kallikrein affinity column selectively isolated 0.013 % of the protein and 0.67 % of the trypsin inhibitory activity present. The majority of the trypsin inhibitory activity present in the starting supernatant did not bind to the immobilized kallikrein and is not related to bikunin (results not shown). Subsequent chromatography using C18 reverse-phase yielded a further purification of 5-fold, with a recovery of 0.2%. The final preparation was highly pure by SDS-PAGE (Figure 13), exhibiting an Mr of 21.3 kDa, and reacted on immunoblots to rabbit anti-placental bikunin 102-159 (not shown). N-terminal sequencing (26 cycles) yielded the expected sequence for mature placental bikunin (Figure 4F) starting at residue +1(ADRER....) , showing that the signal peptide was correctly processed in Sf9 cells.

Purified placental bikunin from Sf9 cells (100 pmol) was pyridylethyl-alkylated, CNBr digested and then sequenced without resolution of the resulting fragments. Sequencing for 20 cycles yielded the following N-terminii:

Sequence	Amount	Placental bikunin residue #
LRCFrQQENPP-PLG-----	21 pmol	154 - 168 (SEQ ID NO.: 63)
ADRERSIHDFCLVSKVVGRC	20 pmol	1 - 20 (SEQ ID NO.: 64)
FNYeEYCTANAVTGPCRASf	16 pmol	100 - 119 (SEQ ID NO.: 65)

Pr--Y-V-dGS-Q-F-Y-G

6 pmol

25 - 43 (SEQ ID NO.: 66)

Thus N-termini corresponding to each of the expected four fragments were recovered. This confirms that the Sf9 expressed protein contained the entire ectodomain sequence of placental bikunin (1-170).

Example 10

Inhibition specificity of purified placental bikunin derived from Sf9 cells.

The *in vitro* specificity of recombinant bikunin was determined using the materials and methods as described in Examples 3, 4 and 7. In addition, the inhibition of human tissue kallikrein by bikunin was measured by the incubation of 0.35 nM human tissue kallikrein recombinant bikunin in buffer containing 50 mM Tris (pH 9.0), 50 mM NaCl, and 0.01% triton x-100. After 5 min. at 37°C, 5 µl of 2 mM PFR-AMC was added and the change in fluorescence monitored.

Inhibition of tissue plasminogen activator (tPA) was also determined as follows: tPA (single chain form from human melanoma cell culture from Sigma Chemical Co, St Louis, MO) was pre-incubated with inhibitor for 2 hr at room temperature in 20 mM Tris buffer pH 7.2 containing 150 mM NaCl, and 0.02% sodium azide. Reactions were subsequently initiated by transfer to a reaction system comprising the following initial component concentrations: tPA (7.5 nM), inhibitor 0 to 6.6 µM, Dile-Lpro-Larg-pNitroaniline (1mM) in 28 mM Tris buffer pH 8.5 containing 0.004 % (v/v) triton x-100 and 0.005% (v/v) sodium azide. Formation of p-Nitroaniline was determined from the A405nm measured following incubation at 37 C for 2hr.

The table below show the efficacy of recombinant bikunin as an inhibitor of various serine proteases *in vitro*. Data is shown compared against data obtained for screening inhibition using either recombinant bikunin, or aprotinin.

Table 9 Comparisons of Ki values for the inhibition of various proteases by recombinant placental bikunin (1-170) or aprotinin

TABLE 9		
Protease (concentration)	Recombinant Bikunin Ki (nM)	Aprotinin Ki (nM)
Trypsin (48.5 pM)	0.064	0.8
Human Plasma Kallikrein (2.5 nM)	0.18	19.0
Human Tissue Kallikrein (0.35 nM)	0.04	0.004
Bovine Pancreatic Kallikrein (100 pM)	0.12	0.02
Human Plasmin (50 pM)	0.23	1.3
factor Xa (0.87 nM)	180	5% Inhibition at 31 μ M
factor XIa (0.1 nM)	3.0	288
tissue plasminogen activator (7.5 nM)	< 60	no inhibition at 6.6 μ M
Tissue Factor VIIa	800	no inhibition at 1 μ M

The results show that recombinant bikunin can be expressed in insect cells to yield an active protease inhibitor that is effective against at least five different serine protease inhibitors. Recombinant bikunin was more potent than aprotinin against human plasma kallikrein, trypsin and plasmin. Surprisingly, the recombinant bikunin was more potent than the synthetically derived bikunin fragments (7-64) and (102-159) against all enzymes tested. These data show that recombinant bikunin is more effective than aprotinin, using *in vitro* assays, and that one would expect better *in vivo* potency.

Besides measuring the potencies against specific proteases, the capacity of placental bikunin (1-170) to prolong the activated partial thromboplastin time (APTT) was evaluated and compared with the activity associated with aprotinin. Inhibitor was diluted in 20 mM Tris buffer pH 7.2 containing 150 mM NaCl and 0.02% sodium azide and added (0.1 ml) to a cuvette contained within an MLA Electra^R 800 Automatic Coagulation Timer coagulometer (Medical Laboratory Automation, Inc., Pleasantville, N.Y.). The instrument was set to APTT mode with a 300 sec. activation time and the duplicate mode. Following addition of 0.1 ml of plasma (Specialty Assayed Reference Plasma lot 1-6-5185, Helena Laboratories, Beaumont, TX), the APTT reagent (Automated APTT-lot 102345, from Organon Teknika Corp., Durham, NC) and 25 mM CaCl₂ were automatically dispensed to initiate clotting, and the clotting time was monitored automatically. The results (Figure 14) showed that a

doubling of the clotting time required approximately 2 μ M final aprotinin, but only 0.3 μ M Sf9 derived placental bikunin. These data show that placental bikunin is an effective anticoagulant, and usefull as a medicament for diseases involving pathologic activation of the intrinsic pathway of coagulation.

Example 11

Measurement of Tracheal Potential Difference in the Guinea-pig

The aim of this study was to investigate the effect of the Kunitz serine protease inhibitor Bikunin, and the sodium channel blocker amiloride on guinea-pig tracheal potential difference 3 hours post treatment. These agents were delivered into the cephalad trachea by topical instillation. TPD was monitored 2 hours later for 60 minutes. The procedure used in this Example is described in Newton et al. in "Cilia, Mucus and Mucociliary Interactions," Ed., Baum, G.L. et al., Marcel Dekker, New York, 1998; Newton et al., Ped. Pulm. S17, Abs. 364, 1998).

Materials and methods/Reagents used

Aqueous formulations of Bikunin (5 and 50 μ g/mL (SEQ ID NO: 52)) and amiloride (obtained from Sigma Chemicals, St. Louis, MO, USA)(100 μ M) were prepared, sterile filtered and endotoxin tested prior to use. These formulations were prepared in Hank's Balanced salt solution (HBSS) and contained 137 mM NaCl, 3 mM KCl, 3 mM KH_2PO_4 , 8 mM Na_2HPO_4 , 0.2% Tween-80, pH 7.1) was prepared, sterile filtered and endotoxin tested for use in this example. HBSS was used as a control solution. Hypnorm® (Fentanyl citrate 0.315 mg/mL and Fluanisone 10 mg/mL) was obtained from Janssen Animal Health and Hypnovel® (Midazolam 5 mg/mL) was obtained from Roche. Male Dunkin-Hartley guinea pigs (550-750 g) were supplied by David Hall, UK. Thermistor probes were obtained from Kane-May Ltd, UK.

Induction of anaesthesia and administration of Bikunin into tracheal airway

Animals were anaesthetised using halothane. Once a satisfactory level of anaesthesia was induced a small incision was made below the lower jaw. The trachea was exposed and 100 μ l volume of vehicle, bikunin (0.5 μ g or 5 μ g) or amiloride (100 μ M) was instilled onto the tracheal surface using a needle and syringe. Once injected, the skin incision was sealed using Vetbond® (cyanocacrylate tissue glue). The animals were then allowed to recover.

Preparation of guinea-pig for measurement of tracheal potential difference

Two hours following agent treatment, guinea-pigs were anaesthetised for a

second time with Hypnom® and Hypnovel® and immobilised in a supine position. Rectal temperature, measured with a thermistor probe was maintained at 37° C by manual adjustment of a heat lamp. A ventral midline incision was made from the lower jaw to the clavicles. Using blunt dissection a length of trachea was exposed and bisected at the upper edge of the sternum. The external jugular vein was exposed and cannulated. The caudal part of the trachea was then cannulated to allow the animal to spontaneously breathe room air. The animal was then placed supine and its body temperature maintained using the heat lamp. 20 min. following induction of i.v. anaesthesia the tracheal agar electrode was inserted into the cephalad trachea and tracheal potential difference was measured for 60 minutes. The reference electrode was placed under cephalad trachea in contact with the trachea cartilage. The wound site was covered to prevent drying.

Results

As shown in Figure 15, Bikunin (5 ug) inhibited the potential difference in guinea pig trachea in vivo following three hours of treatment relative to vehicle. The effect of Amiloride (100 uM) and Bikunin (0.5 ug) is shown for comparison.

Experiment 12

The Effect of Bikunin on Tracheal Mucus Velocity in the Guinea-pig

The aim of this study was to investigate the effect of the Kunitz family serine protease inhibitor Bikunin on guinea-pig tracheal mucus velocity 1.5 hours post treatment. This agent was delivered into the cephalad trachea by topical instillation. TMV was monitored 1.5 hours later for 60 mins. The procedure used in this Example is described in Newton et al. in "Cilia, Mucus and Mucociliary Interactions," Ed., Baum, G.L. et al., Marcel Dekker, New York, 1998; Newton et al., Ped. Pulm. S17, Abs. 364, 1998).

Materials and methods/Reagents used:

A Bikunin formulation (50 ug/mL Bikunin (SEQ ID NO: 52) was prepared in HBBS containing 137 mM NaCl, 3 mM KCl, 3 mM KH₂PO₄, 8 mM Na₂HPO₄, 0.2% Tween-80, pH 7.1). The formulation was sterile filtered and endotoxin tested prior to use in this example. HBSS was used as a control solution. Hypnorm® (Fentanyl citrate 0.315 mg/mL and Fluanisone 10 mg/mL) was obtained from Janssen Animal Health and Hypnovel® (Midazolam 5 mg/mL) was obtained from Roche. Male Dunkin-Hartley guinea pigs (550-750 g) were supplied by David Hall, UK. Thermistor probes were obtained from Kane-May Ltd, UK.

Induction of anaesthesia and administration of Bikunin into tracheal airway

Animals were anaesthetized using halothane. Once a satisfactory level of anaesthesia was induced, a small incision was made below the lower jaw. The trachea was exposed and 100 ul volume of vehicle or bikunin (5 ug) was instilled onto the tracheal surface using a needle and syringe. Once instilled, the skin incision was sealed using Vetbond® (cyanocacrylate tissue glue). The animals were then allowed to recover.

Measurement of tracheal mucus velocity(TMV)

TMV was monitored using a lead collimated miniature Beta particle detector probe arranged to detect the radioactivity emitted from an injected aliquot of ³²P-labelled *Saccharomyces cerevisiae* as it was transported on the tracheal mucociliary layer of an anaesthetized guinea pig (Newton and Hall 1998) Figure 16(a) illustrates the arrangement of the syringe and beta probe. Figure 16(b) illustrates the counts detected by the probe as the ³²P-labelled *S.cerevisiae* is transported along the tracheal mucociliary layer.

70 minutes following instillation of bikunin, each animal was anaesthetized for a second time using Hyponorm® and Hyponovel® and immobilized in a supine position. The first TMV measurement was made 20 minutes afterwards. Subsequent measurements were taken every 15 minutes. The procedure for TMV measurements is described, in detail, in Newton et al., "Cilia. Mucus and Mucociliary Interactions." Ed. Baum, G.L., Preil, Z., Roth, Y., Liron., Ostfield, E., Marcel Dekker. New York, 1990 and Newton et al. in *Pediatric Pulmonology* S17, Abs 364, 1998.

Results

As shown in Figure 16(c), Bikunin (5 ug) increased TMV in vivo in guinea pig, relative to saline, over a sustained period of 1.5 to 2.5 hours following administration.

Experiment 13

Bikunin decreases sodium current in cultured human bronchial epithelial (HBE) cell short circuit current (Isc) in vitro.

Tertiary HBE cell monolayers grown to confluence were mounted in modified Ussing chambers, immersed in Krebs buffer (KBR) solution and bubbled with 95%O₂/5%CO₂ warmed to 37C.

Cells were left to equilibrate for 20 minutes before calibrating for background noise and fluid resistance. Transepithelial potential difference was then clamped to 0 mV using a WPI EVC 4000 voltage clamp. Ag/ AgCl electrodes were used to monitor

was administered. The radiolabelled tracer particles were given via the 0.5 um hole made in the trachae. An aerosol of ether saline (0.9%) or hypertonic saline (14.4%) was generated by a Pari pressure nebulizer. The aerosol was switched off one minute before the second run. The procedure for TMV measurements is described, in detail, in Newton et al., "Cilia, Mucus and Mucociliary Interactions." Ed. Baum, G.L., Preil, Z., Roth, Y., Liron., Ostfield, E., Marcel Dekker. New York, 1990 and Newton et al. in *Pediatric Pulmonology* S17, Abs 364, 1998.

Results

As shown in Figure 18, hypertonic saline (14.4% x 5 mins) caused a transient increase in TMV immediately after aerosol.

Experiment 15

Effect of Amiloride on TMV in the Guinea-pig

The aim of this study was to investigate the effect of amiloride (10mM x 20 min.) on guinea-pig tracheal mucus in the anaesthetized spontaneously breathing guinea pig. This agent was delivered into the cephalad trachea by aerosolization as described in Example 14. The TMV measurement procedure used in this Example is described in Newton et al. in "Cilia, Mucus and Mucociliary Interactions," Ed., Baum, G.L. et al., Marcel Dekker, New York, 1998; Newton et al., *Ped. Pulm.* S17, Abs. 364, 1998).

Materials and methods/Reagents used

An amiloride formulation (10 mM) in water was prepared for this example. Hypnorm® (Fentanyl citrate 0.315 mg/mL and Fluanisone 10 mg/mL) was obtained from Janssen Animal Health and Hypnovel® (Midazolam 5 mg/mL) was obtained from Roche. Male Dunkin-Hartley guinea pigs (550-750 g) were supplied by Harlan UK Ltd. Thermistor probes were obtained from Kane-May Ltd, UK.

Measurement of tracheal mucus velocity

Animals were anaesthetized using Hypnorm® and Hypnovel®. TMV was monitored using a lead collimated miniature Beta particle detector probe arranged to detect the radioactivity emitted from an injected aliquot of ³²P-labelled *Saccharomyces cerevisiae* as it was transported on the tracheal mucociliary layer of an anaesthetized guinea pig. Guinea pigs were anaesthetized with Hypnorm® and Hypnovel at time 0. Amiloride (10mM x 20 min) was administered with Hypnorm® and Hypnovel at t = 0. Amiloride (10 mM x 20 min) was administered by aerosol. The first TMV

measurement was made immediately afterwards and subsequent measurements were taken every 15 minutes.

Results

- 5 As shown in Figure 19, amiloride (10 mM x 20 mins) caused a statistically significant increase in TMV 15 minutes after aerosol.

Example 16

10 Aprotinin double mutein decreases sodium current in cultured human bronchial epithelial (HBE) cell short circuit current (Isc)

- The aim of this study was to investigate the effect of the Kunitz family serine protease inhibitor Aprotinin double mutein on Isc in vitro. Tertiary HBE cell monolayers grown to confluence were mounted in modified Ussing chambers, immersed in Krebs buffer (KBR) solution and bubbled with 95%
15 O₂/5%CO₂ warmed to 37C. Aprotinin double mutein is Des Pro2-Ser10-Arg15-Asp24-Thr26-Glu31-Asn41-Glu53-Aprotinin which is described in Example 1 of EP 821 007, published January 28, 1998, incorporated by reference in its entirety.

- Cells were left to equilibrate for 20 minutes before calibrating for background noise and fluid resistance. Transepithelial potential difference was
20 then clamped to 0 mV using a WPI EVC 4000 voltage clamp. Ag/AgCl electrodes were used to monitor Isc. Once a stable baseline was achieved (typically 10-20 mins), cells were treated with a amiloride (10uM). Once a response to amiloride was seen, it was washed out with KBR solution. After return to baseline and equilibration, Bikunin (5 ug/mL), Aprotinin double
25 mutein (0.5 to 5 ug/mL), Aprotinin (1.5 to 5 ug/mL) or PBS was added. 90 minutes following agent treatment, amiloride (10uM) was added.

Results

- As shown in Figure 20, Aprotinin double mutein (0.5 to 5 ug/mL) dose
30 dependently inhibited sodium current in vitro in human bronchial epithelial cells over a 90 minute period.

- Although certain embodiments of the invention have been described in detail for the purpose of illustration, it will be readily apparent to those skilled in the art that the methods and formulations described herein may be modified
35 without departing from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

WE CLAIM:

1. A method for accelerating the rate of mucociliary clearance in a subject in need of such treatment comprising administering to the subject an effective mucociliary clearance stimulatory amount of a composition comprising a Kunitz-type serine protease inhibitor and a physiologically acceptable carrier.

2. The method according to claim 1, wherein the composition is administered to the lung airways.

3. The method according to claim 1, wherein said composition is administered directly by aerosolization.

4. The method according to claim 1, wherein said composition is administered directly as an aerosol suspension into the mammal's respiratory tract.

5. The method according to claim 4, wherein said aerosol suspension includes respirable particles ranging in size from about 1 to about 10 microns.

6. The method according to claim 4, wherein said aerosol suspension includes respirable particles ranging in size from about 1 to about 5 microns.

7. The method according to claim 4, wherein said aerosol suspension is delivered to said subject by a pressure driven nebulizer.

8. The method according to claim 4, wherein said aerosol suspension is delivered to said subject by an ultrasonic nebulizer.

9. The method according to claim 4, wherein said aerosol suspension is delivered to said subject by a non-toxic propellant.

10. The method according to claim 1, wherein said carrier is a member selected from the group consisting of a physiologically buffered solution, an isotonic saline, normal saline, and combinations thereof.

11. The method according to claim 1 wherein the Kunitz-type serine protease inhibitor is aprotinin.

12. The method according to claim 1, wherein the Kunitz-type serine protease inhibitor comprises the amino acid sequence:

MAQLCGL RRSRAFLALL GLLLLSGVLA -1

ADRERSIHDF CLVSKVVGRC RASMPRWYN VTDGSCQLFV YGGCDGNSNN 50
YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
ACMLRCFRQQ ENPPLPLGSK VVVLAGLFVM VLILFLGASM VYLIRVARRN 200
QERALRTVWS SGDDKEQLVK NTYVL 225
(SEQ ID NO.: 49) .

NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 ACMLRCFRQQ ENPPLPLGSK VVVLAGLFVM VLILFLGASM VYLIRVARRN 200
 QERALRTVWS FGD 213
 (SEQ ID NO.: 71).

5

14. The method according to claim 1, wherein the Kunitz-type serine protease inhibitor comprises the amino acid sequence:

10 IHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 YLTKEECLKK CATV 64
 (SEQ ID NO.: 4),

CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 15 YLTKEECLKK C 61
 (SEQ ID NO.: 5),

YEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 ACMLRCFRQ 159
 20 (SEQ ID NO.: 6),

CTANAVTGPC RASFPRWYFD VERNSCNNFI YGGCRGNKNS YRSEE 150
 ACMLRC 156
 (SEQ ID NO.: 7),

25 IHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 75
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 125
 ACMLRCFRQ 159
 30 (SEQ ID NO.: 3),

CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 35 ACMLRC 156
 (SEQ ID NO.: 50),

ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 25

YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 75
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 125
 ACMLRCFRQQ ENPPLPLGSK VVVLGAVS 179
 (SEQ ID NO.: 1),

5

and

ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN
 50

10 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF
 100

NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE
 150

ACMLRCFRQQ ENPPLPLGSK 170

15 (SEQ ID NO.: 52).

15. The method according to claim 1, wherein the Kunitz-type serine
 protease inhibitor comprises the amino acid sequence:

20 ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DS 92
 (SEQ ID NO.: 8).

25 16. The method according to claims 12, 13, 14 or 15, wherein the Kunitz-
 type serine protease inhibitor is glycosylated.

17. The method according to claims 12, 13, 14 or 15, wherein the Kunitz-
 type serine protease inhibitor contains at least one intra-chain cysteine-cysteine
 disulfide bond.

30

18. The method according to claims 12, 13, 14, or 15, wherein the Kunitz-
 type serine protease inhibitor contains at least one intra-chain cysteine-cysteine
 disulfide bond selected from the cysteine-cysteine paired groups consisting of
 CYS11-CYS61, CYS20-CYS44, CYS36-CYS57, CYS106-CYS156, CYS115-CYS139,
 35 and CYS131-CYS152, wherein the cysteine residues are numbered according to
 the amino acid sequence of native human placental bikunin.

19. Use of a Kunitz-type serine protease inhibitor in manufacturing a medicament for accelerating the rate of mucociliary clearance in a subject in need of such treatment.

20. Use according to claim 19, wherein the Kunitz-type serine protease inhibitor is in a form suitable for administration to lung airways.

21. Use according to claim 19, wherein the Kunitz-type serine protease inhibitor is in a form suitable for administration by aerosolization.

22. Use according to claim 19, wherein the Kunitz-type serine protease inhibitor is in a form suitable for administration as an aerosol suspension into the mammal's respiratory tract.

23. Use according to claim 22, wherein said aerosol suspension includes respirable particles ranging in size from about 1 to about 10 microns.

24. Use according to claim 22, wherein said aerosol suspension includes respirable particles ranging in size from about 1 to about 5 microns.

25. Use according to claim 22, wherein said aerosol suspension is generated by pressure driven nebulizer.

26. Use according to claim 22, wherein said aerosol suspension is generated by an ultrasonic nebulizer.

27. Use according to claim 22, wherein said aerosol suspension includes a non-toxic propellant.

28. Use according to claim 19, wherein medicament includes a carrier selected from the group consisting of a physiologically buffered solution, an isotonic saline, normal saline, and combinations thereof.

29. Use according to claim 19, wherein the Kunitz-type serine protease inhibitor is aprotinin.

31. Use according to claim 19, wherein the Kunitz-type serine protease inhibitor comprises the amino acid sequence:

```
MAQLCGL RRSRAFLALL GSLLLSGVLA -1
ADRSRSHDF CLVSKVVGRC RASMPRWYN VTDGSCQLFV YGGCDGNSNN 50
30 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
ACMLRCFRQQ ENPPLPLGSK VVVLAGLFVM VLILFLGASM VYLIRVARRN 200
QERALRTVWS SGDDKEQLVK NTYVL 225
(SEQ ID NO. : 49) .
```

32. Use according to claim 19, wherein the Kunitz-type serine protease inhibitor comprises the amino acid sequence:

AGSFLAWL GSLLLLSGVLA -1
 ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 5 ACMLRCFRQQ ENPPLPLGSK VVVLGAVS 179
 (SEQ ID NO.: 2),

MLR AEADGVSRLI GSLLLLSGVLA -1
 ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 10 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 ACMLRCFRQQ ENPPLPLGSK VVVLAGLFVM VLILFLGASM VYLIRVARRN 200
 QERALRTVWS SGDDKEQLVK NTYVL 225
 (SEQ ID NO.: 45),

15 MAQLCGL RRSRAFLALL GSLLLLSGVLA -1
 ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 20 ACMLRCFRQQ ENPPLPLGSK VVVLAGLFVM VLILFLGASM VYLIRVARRN 200
 QERALRTVWS FGD 213
 (SEQ ID NO.: 47),

ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 25 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 ACMLRCFRQQ ENPPLPLGSK VVVLAGLFVM VLILFLGASM VYLIRVARRN 200
 QERALRTVWS SGDDKEQLVK NTYVL 225
 (SEQ ID NO.: 70),

30

and

ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
 35 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
 ACMLRCFRQQ ENPPLPLGSK VVVLAGLFVM VLILFLGASM VYLIRVARRN 200
 QERALRTVWS FGD 213

(SEQ ID NO.: 71).

33. Use according to claim 19, wherein the Kunitz-type serine protease
5 inhibitor comprises the amino acid sequence:

IHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
YLTKEECLKK CATV 64
(SEQ ID NO.: 4),

10

CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
YLTKEECLKK C 61
(SEQ ID NO.: 5),

15

YEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
ACMLRCFRQ 159
(SEQ ID NO.: 6),

20

CTANAVTGPC RASFPRWYFD VERNSCNNFI YGGCRGNKNS YRSEE 150
ACMLRC 156
(SEQ ID NO.: 7),

25

IHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 75
NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 125
ACMLRCFRQ 159
(SEQ ID NO.: 3),

30

CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 100
NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 150
ACMLRC 156
(SEQ ID NO.: 50),

35

ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 25
YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF 75
NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE 125
ACMLRCFRQQ ENPPLPLGSK VVVLGAVS 179

(SEQ ID NO.: 1),

and

5 ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN
 50
 YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DSEDHSSDMF
 100
 NYEEYCTANA VTGPCRASFP RWYFDVERNS CNNFIYGGCR GNKNSYRSEE
10 150
 ACMLRCFRQQ ENPPLPLGSK 170
 (SEQ ID NO.: 52).

34. Use according to claim 19, wherein the Kunitz-type serine protease
15 inhibitor comprises the amino acid sequence:

ADRERSIHDF CLVSKVVGRC RASMPRWWYN VTDGSCQLFV YGGCDGNSNN 50
YLTKEECLKK CATVTENATG DLATSRNAAD SSVPSAPRRQ DS 92
(SEQ ID NO.: 8).

20

35. Use according to claim 19, wherein the Kunitz-type serine protease
inhibitor is glycosylated.

36. Use according to claim 19, wherein the Kunitz-type serine protease
25 inhibitor contains at least one intra-chain cysteine-cysteine disulfide bond.

37. Use according to claim 19, wherein the Kunitz-type serine protease
inhibitor contains at least one intra-chain cysteine-cysteine disulfide bond
selected from the cysteine-cysteine paired groups consisting of CYS11-CYS61,
30 CYS20-CYS44, CYS36-CYS57, CYS106-CYS156, CYS115-CYS139, and CYS131-
CYS152, wherein the cysteine residues are numbered according to the amino
acid sequence of native human placental bikunin.

ABSTRACT

The instant invention provides for a composition and method for using Kunitz-type serine protease inhibitors, e.g., aprotinin or bikunin, for stimulating
5 the rate of mucociliary clearance of mucus and sputum in lung airways of subjects afflicted with mucociliary dysfunctions such as cystic fibrosis.

SECRET

1/48

KEY
R35464 = Nucleic acid sequence of EST R35464 (SEQ ID NO: 12)
ORF = EST R35464 Open Reading Frame Translation (SEQ ID NO: 13)

[illegible]

FIGURE 2

2/48

R74593	GCAATAATTA	CCTGACCAAG	GAGGAGTGCC	TCAAGAAATG	TGCCACTGTC	50
ORF	Q * L	P D Q G	G V P	Q E M	C H C H	17
R74593	ACAGAGAATG	CCACGGGTGA	CCTGGCCACC	AGCAGGAATG	CAGCGGATTC	100
ORF	R E C	H G *	P G H Q	Q E C	S G F	33
R74593	CTCTGTCCCA	AGTCTCCCAG	AAGGCAGGAT	TCTGAAGACC	ACTCCAGCGA	150
ORF	L C P K	S P R	R Q D	S E D H	S S D	50
R74593	TATGTTCAAC	TATGAAGAAT	ACTGCACCGC	CAACGCAGTC	ACTGGGCCTT	200
ORF	M F N	Y E E Y	C T A	N A V	T G P C	67
R74593	GCCGTGCATC	CTTCCCACGC	TGGTACTTTG	ACGTGGAGAG	GAACTCCTGC	250
ORF	R A S	F P R	W Y F D	V E R	N S C	83
R74593	AATAACTTCA	TCTATGGAGG	CTGCCGGGGC	AATAAGAACA	GCTACCGCTC	300
ORF	N N F I	Y G G	C R G	N K N S	Y R S	100
R74593	TGAGGAGGCC	TGCATGCTCC	GCTGCTTCCG	CCAGCAGGAG	AATCCTCCCC	350
ORF	E E A	C M L R	C F R	Q Q E	N P P L	117
R74593	TGCCCCCTTG	CTCAAAGGTG	GTGGTTCTGG	CCGGGGCTGT	TTCGTGATGG	400
ORF	P L G	S K V	V V L A	G A V	S * W	133
R74593	TGTTGATCCT	TTTCCTGGGG	AGCNTCCATG	GTCTTACTGA	TTCCGGGTGG	450
ORF	C * S F	S W G	A S M	V L L I	P G G	150
R74593	CAAGGAGGAA	CCAGGAGCGT	GCCCTGCGGA	NCGTCTGGAG	CTTCGGAGAT	500
ORF	K E E	P G A C	P A X	R L E	L R R *	167
R74593	GACAAGGGNT					510
ORF	Q G					169

KEY

R74593 = Nucleic acid sequence of EST R74593 (SEQ ID NO: 14)

ORF = EST R74593 Open Reading Frame Translation (SEQ ID NO: 15)

EST R74593

FIGURE 3

3/48

R35464	GGCCGGGTCGT	TTCTCGCCTG	GCTGGGA-TC	GCTGCTCCTC	TCTGGGGTCC	50
N39798			TGGGANTC	GCTGCTCCTC	TCTGGGGTCC	28
H94519	GCNCG-CGT	TNNTCGCNT-	GCTGGGA-TC	GCTGCACCTC	TCTGGGGTCC	47
R74593 corr.	-----	-----	-----	-----	-----	
Consensus	GGCCGGGTCGT	TTCTCGCCTG	GCTGGGA-TC	GCTGCTCCTC	TCTGGGGTCC	50
Translation	A G S F	L A W	L G S	L L L	S G V	-3
R35464	TGGCCGGCCG	ACCGAGAACG	CAGCATCCAC	GACTTCTGCC	TGGTGTGCGAA	100
N39798	TGG-CGGCCG	ACCGAGAACG	CAGCATCCAC	GACTTCTGCC	TGGTGTGCGAA	77
H94519	NGG-CGGCCG	ACCGAGAACG	CAGCATCCAC	GACTTCTGCC	TGGTGTGCGAA	96
R74593 corr.	-----	-----	-----	-----	-----	
Consensus	TGG-CGGCCG	ACCGAGAACG	CAGCATCCAC	GACTTCTGCC	TGGTGTGCGAA	99
Translation	L A A D	B E B	S I H	D E C L	Y S K	15
R35464	GGTGGTGGGC	AGATTCCGGG	CCTCCATGCC	TAGGTGGTGG	TACAATGTCA	150
N39798	GGTGGTGGGC	AGATGCCGGG	CCTCCATGCC	TAGGTGGTGG	TACAATGTCA	127
H94519	GGTGGTGGGC	AGATGCCGGG	CCTCCATGCC	TAGGTGGTGG	TACAATGTCA	146
R74593 corr.	-----	-----	-----	-----	-----	
Consensus	GGTGGTGGGC	AGATGCCGGG	CCTCCATGCC	TAGGTGGTGG	TACAATGTCA	149
Translation	Y Y G	R C B A	S M P	B W H	Y N Y T	32
R35464	CTGACGGATC	CTGCCAGCTG	TTTGTGTATG	GGGGCTGTGA	CGGAAACAGC	200
N39798	CTGACGGATC	CTGCCAGCTG	TTTGTGTATG	GGGGCTGTGA	CGGAAACAGC	177
H94519	CTGACGGATC	CTGCCAGCTG	TTTGTGTATG	GGGGCTGTGA	CGGAAACAGC	196
R74593 corr.	-----	-----	-----	-----	-----GC	2
Consensus	CTGACGGATC	CTGCCAGCTG	TTTGTGTATG	GGGGCTGTGA	CGGAAACAGC	199
Translation	D G S	C Q L	E Y X G	G C D	G N S	48
R35464	AATAATTACC	TGACCAAGGA	GGAGTGCCTC	AAGAAATGTG	CCACTGTCAC	250
N39798	AATAATTACC	TGACCAAGGA	GGAGTGCCTC	AAGAAATGTG	CCACTGTCAC	227
H94519	AATAATTACC	TGACCAAGGA	GGAGTGCCTC	AAGAAATGTG	CCACTGTCAC	246
R74593 corr.	AATAATTACC	TGACCAAGGA	GGAGTGCCTC	AAGAAATGTG	CCACTGTCAC	52
Consensus	AATAATTACC	TGACCAAGGA	GGAGTGCCTC	AAGAAATGTG	CCACTGTCAC	249
Translation	N N Y L	T K E	E C L	K K C A	T V T	65
R35464	AGAGAATGCC	ACGGGTGACC	TGGCCACCAG	CAGGAATGCA	GCGGATTCCCT	300
N39798	AGAGAATGCC	ACGGGTGACC	TGGCCACCAG	CAGGAATGCA	GCGGATTCCCT	277
H94519	AGAGAATGCC	ACGGGTGACC	TGGCCACCAG	CAGGAATGCA	GCGGATTCCCT	296
R74593 corr.	AGAGAATGCC	ACGGGTGACC	TGGCCACCAG	CAGGAATGCA	GCGGATTCCCT	102
Consensus	AGAGAATGCC	ACGGGTGACC	TGGCCACCAG	CAGGAATGCA	GCGGATTCCCT	299
Translation	E N A	T G D L	A T S	R N A	A D S S	82
R35464	CTGTCCCAAG	TGCTCCCAGA	AGGCAGGATT	CTTGAAGACC	ACTTCAGCGA	350
N39798	CTGTCCCAAG	TGCTCCCAGA	AGGCAGGATT	CT-GAAGACC	ACTCCAGCGA	326
H94519	CTGTCCCAAG	TGCTCCCAGA	AGGCAGGATT	CT-GAAGACC	ACTCCAGCGA	345
R74593 corr.	CTGTCCCAAG	TGCTCCCAGA	AGGCAGGATT	CT-GAAGACC	ACTCCAGCGA	151
Consensus	CTGTCCCAAG	TGCTCCCAGA	AGGCAGGATT	CT-GAAGACC	ACTCCAGCGA	348
Translation	V P S	A P R	R Q D S	E D H	S S D	98
R35464	TATGTTTCAA	NTATTGNAAG	AATAATTGCA	CCGNCAACGN	ATT-----	393
N39798	TATGTT-CAA	CTA-TG-AAG	AATACT-GCA	CCGCCAACGC	AGTCACTGGG	372
H94519	TATGTT-CAA	CTA-TG-AAG	AATACTGGCA	CCGCCAACGC	ATTCACTGGG	392
R74593 corr.	TATGTT-CAA	CTA-TG-AAG	AATACT-GCA	CCGCCAACGC	AGTCACTGGG	197
Consensus	TATGTT-CAA	CTA-TG-AAG	AATACT-GCA	CCGCCAACGC	AGTCACTGGG	394
Translation	M F N	Y E E	Y C T	A N A	V T G	113

FIGURE 3 (CONT)

4/48

R35464	-----	-----	-----	-----	-----	
N39798	CCTTGC-GTG	GAATCCTTTC	CCACGCTGGN	AATTTNGACG	TTGAGAAGGA	421
H94519	CCT-GC-GTG	-CATCCTT-C	CCACGCTGGT	ACTTT-GNCG	-----	427
R74593 corr.	CCTTGCCGTG	-CATCCTT-C	CCACGCTGGT	ACTTT-GACG	TGGAGA-GGA	243
Consensus	CCTTGCCGTG	-CATCCTT-C	CCACGCTGGT	ACTTT-GACG	TGGAGA-GGA	440
Translation	P C R A	S F	P R W Y	F D V	E R N	129

R35464	-----	-----	-----	-----	-----	
N39798	AC-----	-----	-----	-----	-----	423
H94519	-----	-----	-----	-----	-----	
R74593 corr.	ACTCCTGCAA	TAACTTCATC	TATGGAGGCT	GCCGGGGCAA	TAAGAACAGC	293
Consensus	ACTCCTGCAA	TAACTTCATC	TATGGAGGCT	GCCGGGGCAA	TAAGAACAGC	490
Translation	S C N	N F I	Y G G C	R G N	K N S	145

R35464	-----	-----	-----	-----	-----	
N39798	-----	-----	-----	-----	-----	
H94519	-----	-----	-----	-----	-----	
R74593 corr.	TACCGCTCTG	AGGAGGCCTG	CATGCTCCGC	TGCTTCCGCC	AGCAGGAGAA	343
Consensus	TACCGCTCTG	AGGAGGCCTG	CATGCTCCGC	TGCTTCCGCC	AGCAGGAGAA	540
Translation	Y R S E	E A C	M L R	C F R Q	Q E N	162

R35464	-----	-----	-----	-----	-----	
N39798	-----	-----	-----	-----	-----	
H94519	-----	-----	-----	-----	-----	
R74593 corr.	TCCTCCCCTG	CCCCTTGGCT	CAAAGGTGGT	GGTTCTGGCC	GGGGCTGTTT	393
Consensus	TCCTCCCCTG	CCCCTTGGCT	CAAAGGTGGT	GGTTCTGGCC	GGGGCTGTTT	590
Translation	P P L	P L G S	K V V	V L A	G A V S	179

R35464	-----	-----	-----	-----	-----	
N39798	-----	-----	-----	-----	-----	
H94519	-----	-----	-----	-----	-----	
R74593 corr.	CGTGATGGTG	TTGATCCTTT	TCCTGGGGAG	CNTCCATGGT	CTTACTGATT	443
Consensus	CGTGATGGTG	TTGATCCTTT	TCCTGGGGAG	CNTCCATGGT	CTTACTGATT	640
Translation	* W C	* S F	S W G A	S M V	L L I	195

R35464	-----	-----	-----	-----	-----	
N39798	-----	-----	-----	-----	-----	
H94519	-----	-----	-----	-----	-----	
R74593 corr.	CCGGGTGGCA	AGGAGGAACC	AGGAGCGTGC	CCTGCGGANC	GTCTGGAGCT	493
Consensus	CCGGGTGGCA	AGGAGGAACC	AGGAGCGTGC	CCTGCGGANC	GTCTGGAGCT	690
Translation	P G G K	E E P	G A C	P A * R	L E L	212

R35464	-----	-----				
N39798	-----	-----				
H94519	-----	-----				
R74593 corr.	TCGGAGATGA	CAAGGGNT				511
Consensus	<u>TCGGAGATGA</u>	CAAGGGNT				708
Translation	R R *	Q G				217

KEY

R35464 = Nucleic acid sequence of EST R35464 (SEQ ID NO.: 12)

N39798 = Nucleic acid sequence of EST N39798 (SEQ ID NO.: 17)

H94519 = Nucleic acid sequence of EST H94519 (SEQ ID NO.: 16)

R74593 corr. = Corrected version of (SEQ ID NO.: 14) G at b.p. 114

Consensus = Nucleic acid sequence for human bikunin (SEQ ID NO.: 9)

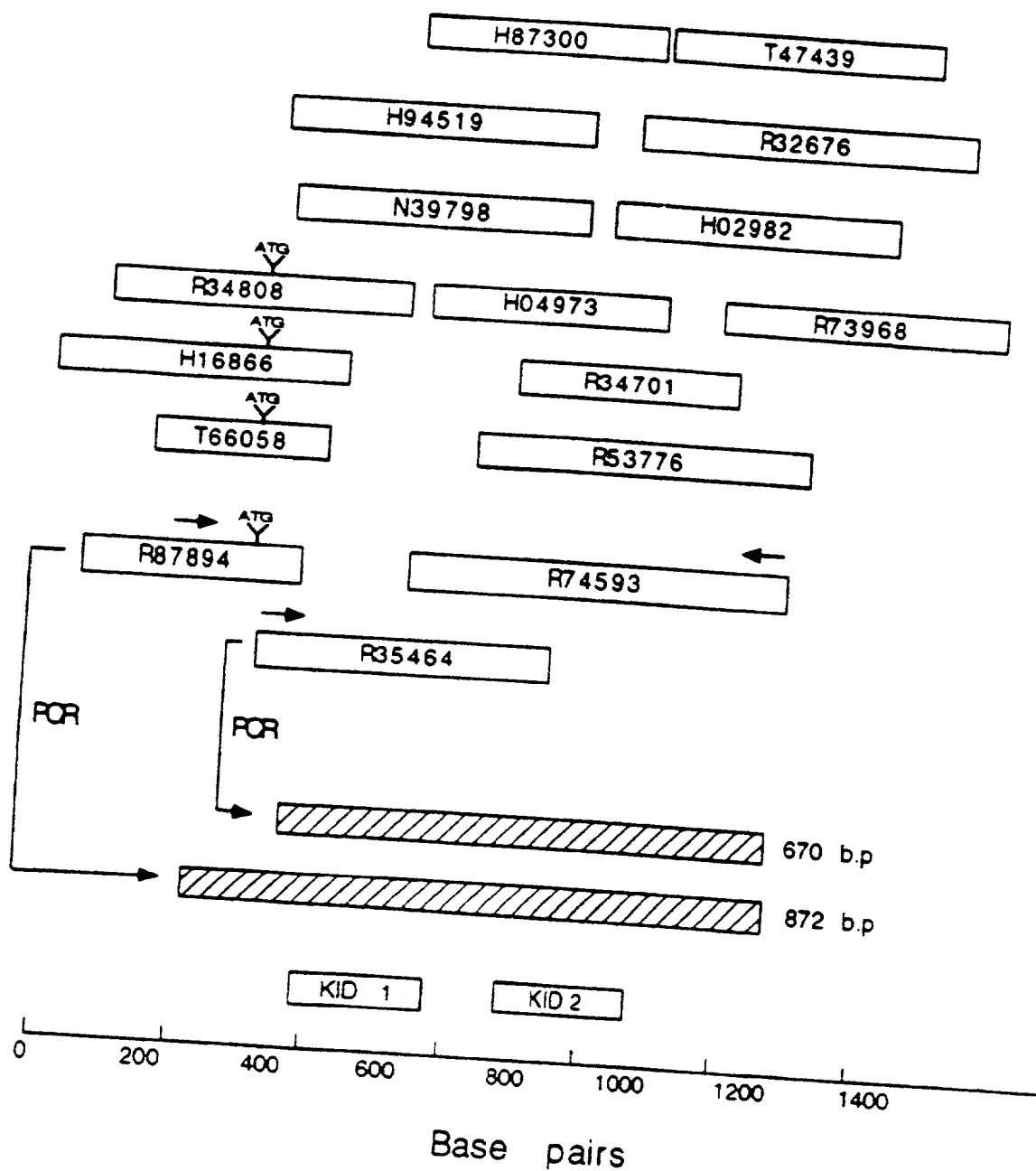
Translation = Amino acid Translation of Consensus (SEQ ID NO.: 10)

Bikunin ESTs

Figure 4 A.

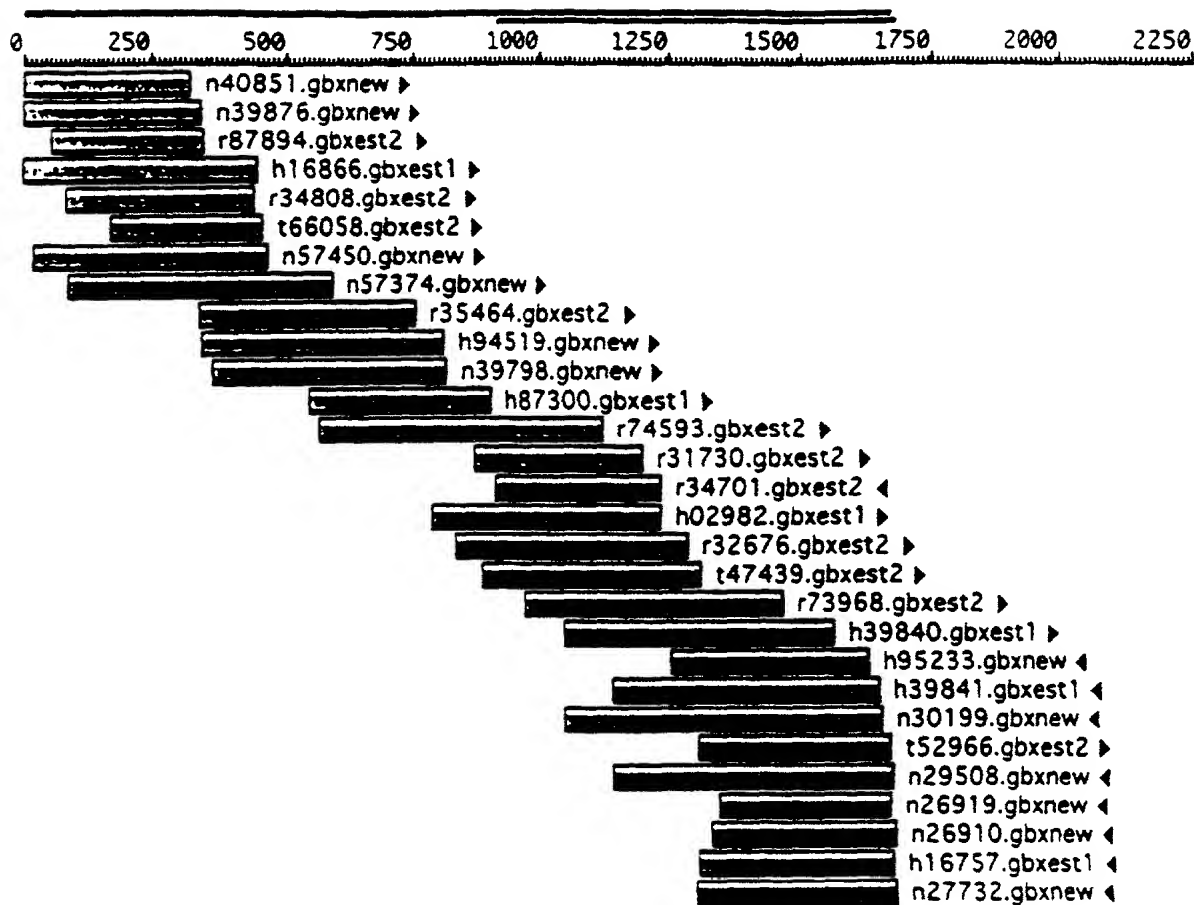
5/48

Schematic depicting the overlap of ESTs bearing homology to the cDNA sequence encoding placental bikunin



6/48

Figure 4B



bioRxiv preprint doi: <https://doi.org/10.1101/012260>; this version posted February 1, 2016. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted bioRxiv a license to display the preprint in perpetuity. It is made available under aCC-BY-NC-ND 4.0 International license.

Figure 4C

	1				50
Bikunin	.....GCGA	CCTCCGCCGC	TTGGGAGGTG	TAGCGCGGCT	CTGAACGGCT
N40851	.....GCGA	CCTCCGCCGC	TTGGGAGGTG	TAGCGCGGCT	CTGAACGGCT
N39876	.....GCGA	CCTCCGCCGC	TTGGGAGGTG	TAGCGCGGCT	CTGAACGGCT
R87894	.....	.....	.....	.....	.....
H16866	....GGCGA	CCTCCGCCGC	TTGGGAGGTG	TAGCGCG.CT	CTGAACGGGN
R34808	.....	.....	.....	.....	.....
T66058	.....	.....	.....	.....	.....
N57450	.....	.....	.....I	TAGCGCGGCT	CTGAACGCNA
N57374	.....	.....	.....	.....	.....
R35464	.....	.....	.....	.....	.....
H94519	.....	.....	.....	.....	.....
N39798	.....	.....	.....	.....	.....
H87300	.....	.....	.....	.....	.....
R74593	.....	.....	.....	.....	.....
R31730	.....	.....	.....	.....	.....
R34701	.....	.....	.....	.....	.....
HQ2982	.....	.....	.....	.....	.....
R32676	.....	.....	.....	.....	.....
T47439	.....	.....	.....	.....	.....
R73968	.....	.....	.....	.....	.....
H39840	.....	.....	.....	.....	.....
H95233	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....
N30199	.....	.....	.....	.....	.....
T52966	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....

1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2629 2630 2631 2632 2633 2634 2635 2636 2637 2638 2639 2640 2641 2642 2643 2644 2645 2646 2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664 2665 2666 2667 2668 2669 2670 2671 2672 2673 2674 2675 2676 2677 2678 2679 2680 2681 2682 2683 2684 2685 2686 2687 2688 2689 2690 2691 2692 2693 2694 2695 2696 2697 2698 2699 2700 2701 2702 2703 2704 2705 2706 2707 2708 2709 2710 2711 2712 2713 2714 2715 2716 2717 2718 2

	5:	100
Bikunin	GNA GGGCCG TTGAGTGTCC CAGGCGGCCA GGGCGCGAGT	GAGGAGCAGA
N40851	NGAGNGGCCG TTGAGTGTCC CAGGCGGCCA GGGCGCGAGT	GAGGAGCAGA
N39876	GCA.GGGCCG TTGAGTGTCC CAGGCGGCCA GGGCGCGAGT	GAGGAGCAGA
R87894	..... TTGAGTGTTC NAGGCGGCCA GGGCGCGAGT	GAGGAGCAGA
H16866	..ANGGCCG TTGAGTGTCC CAGGCGGC.A GGSCN.GAGT	GAGGAGCAGA
R34808	GAGGAGCAGA
T66058
N57450	GAAGNGGCCG TTGAGTGTCC CAGGCGGCCA GGGCGCGAGT	GAGGAGCAGA
N57374AGA
R35464
H94519
N39798
H87300
R74593
R31730
R34701
H02982
R32676
T47439
R73968
H39840
H95233
H39841
N30199
T52966
N29508
N26919
N26910
H16757
N27732

9/48

Figure 4C (Con't)

	101					150
Bikunin	CCCAGGCATC	GCGCGCCGAG	AAGNC	GGGC	GTCCCCACAC	TGAAGGTCCG
N40851	CCCAGGCATC	GCGCGCCGAG	AAGNC	GGGC	GTCCCCACAC	TGAAGGTCCG
N39876	CCCAGGCATC	GCGCGCCGAG	AAGNC	GGGC	NTCCCCACAC	TGAAGGTCCG
R87894	CCCAGGCATC	GCGCGCCGAG	AAGGCCGGGC		GTCCCCACAC	TGAAGGTCCG
H16866	CCCAGGCATC	GCGCGCCGAG	AAGNC	GGGC	GTCCCCACAC	TGAAGGTCCG
R34808	CCCAGGCATC	GCGCGCCGAG	AAGNC	GGGC	GTCCCCACAC	TGAAGGTCCG
T66058	.....	.....	.....	.....	.....	.....
N57450	CCCAGGCATC	GCGCGCCGAG	AAGNC	GGGC	GTCCCCACAC	TGAAGGTCCG
N57374	CCCAGGCATC	GCGCGCCGAG	AAGNC	GGGC	GTCCCCACAC	TGAAGGTCCG
R35464	.....	.....	.....	.....	.....	.....
H94519	.....	.....	.....	.....	.....	.....
N39798	.....	.....	.....	.....	.....	.....
H87300	.....	.....	.....	.....	.....	.....
R74593	.....	.....	.....	.....	.....	.....
R31730	.....	.....	.....	.....	.....	.....
R34701	.....	.....	.....	.....	.....	.....
H02982	.....	.....	.....	.....	.....	.....
R32676	.....	.....	.....	.....	.....	.....
T47439	.....	.....	.....	.....	.....	.....
R73968	.....	.....	.....	.....	.....	.....
H39840	.....	.....	.....	.....	.....	.....
H95233	.....	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....	.....
N30199	.....	.....	.....	.....	.....	.....
T52966	.....	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....	.....

CCAGGCATC

[illegible]

	151		200
Bikunin	GAAAGGCGAC	TTCCGGGGGC	TTTGGCACCT
N40851	GAAAGGCGAC	TTCCGGGGGC	TTTGGCACCT
N39876	GAAAGGCGAC	TTCCGGGGGC	TTTGGCACCT
R87894	GAAAGGCGAC	TTCCGGGGGC	TTTGGCACCT
H16866	GAAAGGCGAC	TTCCGGGGGC	TTTGGCACCT
R34808	GAAAGGCGAC	TTCCGGGGGC	TTTGGCACCT
T66058	.....	.....	...GGACCT
N57450	GAAAGGCGAC	TTCCGGGGGC	TTTGGCACCT
N57374	GAAAGGCGAC	TTCCGGGGGC	TTTGGCACCT
R35464	.....	.....	.....
H94519	.....	.....	.....
N39798	.....	.....	.....
H87300	.....	.....	.....
R74593	.....	.....	.....
R31730	.....	.....	.....
R34701	.....	.....	.....
H02982	.....	.....	.....
R32676	.....	.....	.....
T47439	.....	.....	.....
R73968	.....	.....	.....
H39840	.....	.....	.....
H95233	.....	.....	.....
H39841	.....	.....	.....
N30199	.....	.....	.....
T52966	.....	.....	.....
N29508	.....	.....	.....
N26919	.....	.....	.....
N26910	.....	.....	.....
H16757	.....	.....	.....
N27732	.....	.....	.....

11/48

Figure 4C (Con't)

	201		250
Bikunin	CGGCACCTGA	ACGCGAGGCG	CTCCATTGCG CGTGCCTTTG .AGGGGGCTTC
N40851	CGGCACCTGA	ACGCGAGGCG	CTCCATTGCG CGTGCCTNTG .AGGGGGCTTC
N39876	CGGCACCTGA	ACGCGAGGCG	CTCCATTGCG CGTGCCTTTG .AGGGGGCTTC
R87894	CGGCACCTGA	ACGCGAGGCG	CTCCATTGCG CGTGCCTTTG .AGGGGGCTTC
H16866	.GGCACCTGA	ACGCGAGGCG	CTCCATTGCG CGTGCCTTTG .AGGGGGCTTC
R34808	CGGCACCTGA	ACGCGAGGCG	CTCCATTGCG CGTGCCTNTG GAGGGGGCTTC
T66058	CGGCACCTGA	ACGCGAGGCG	CTCCATTGCG .GTGCCTGTG NAGGGGGCTTC
N57450	CGGCACCTGA	ACGCGAGGCG	CTCCATTGCG CGTGCCTTTG .AGGGGGCTTC
N57374	CGGCACCTGA	ACGCGAGGCG	CTCCATTGCG CGTGCCTTTG .AGGGGGCTTC
R35464	.....	.....	.....
H94519	.....	.....	.....
N39798	.....	.....	.....
H87300	.....	.....	.....
R74593	.....	.....	.....
R31730	.....	.....	.....
R34701	.....	.....	.....
H02982	.....	.....	.....
R32676	.....	.....	.....
T47439	.....	.....	.....
R73968	.....	.....	.....
H39840	.....	.....	.....
H95233	.....	.....	.....
H39841	.....	.....	.....
N30199	.....	.....	.....
T52966	.....	.....	.....
N29508	.....	.....	.....
N26919	.....	.....	.....
N26910	.....	.....	.....
H16757	.....	.....	.....
N27732	.....	.....	.....

Bikunin

12/48

Figure 4C (Con't)

	251				300
Bikunin	CCGCACCT G ATCGCGAGAC CCCAACGGCT	GGTGG CGTC GC TG CGCG			
N40851	CCGCACCT.G ATCGCGAGAC CCCAACGGCT	GGTGG.CGTC GCCTG.CGCG			
N39876	CCGCACCT.G ATCGCGAGAC CCCAACGGCT	GGTGG.CGTC GCCTG.CGCG			
R87894	CCGCACCT.G ATCGCGAGAC CCCAACGGCT	GGTNG.CGTC GC.TN.CGCG			
H16866	CCGCACCT.G ATCGCGAGAC CCCAACGGCT	GGTNG.CGTC GC.TGGCGCG			
R34808	CCGCACCT.G ATCGCGAGAC CCCAACGGCT	GGTGGGCGTC GC.TG.CGCG			
T66058	CCGCACCT.G ATCGCGAGAC CCCAACGGCT	GGTGG.CGTC GC.TG.CGCG			
N57450	CCGCACCT.G ATCGCGAGAC CCCAACGGCT	GGTGG.CGTC GCCTG.CGCG			
N57374	CCGGAACCTG ATCGCGAGAC CCCAACGGCT	GGTGG.CGTC GC.TG.CGCG			
R35464	.....	.....	
H94519	.....	.....	
N39798	.....	.....	
H87300	.....	.....	
R74593	.....	.....	
R31730	.....	.....	
R34701	.....	.....	
H02982	.....	.....	
R32676	.....	.....	
T47439	.....	.....	
R73968	.....	.....	
H39840	.....	.....	
H95233	.....	.....	
H39841	.....	.....	
N30199	.....	.....	
T52966	.....	.....	
N29508	.....	.....	
N26919	.....	.....	
N26910	.....	.....	
H16757	.....	.....	
N27732	.....	.....	

Bikunin "E" EBFED

Figure 4C (Con't)

	301				350
Bikunin	TC TCGGCTG	AGCT GGCCA	TGGCGCANT	GTTGC GGGC	T GAGGC GG
N40851	TC.TCGGCTG	AGCT.GGNCA	TGTGG		
N39876	TC.TCGGCTG	AGCT.GGCCA	TGGCGCACT.	G.TGGCGNGC	T.GAGGC.G
R87894	TC.TCGGCTG	AGCTTGGCCA	TGGCGCANT.	GTTNC.GGGC	T.NAGGC.GG
H16866	TTCTCGGCTG	AGCT.GGCCA	TGGCGCANT.	GTTGC.GNGC	T.GAGGC.GG
R34808	TTCTCGGCTG	AGCTGGGCCA	TGGCGCANTT	GTTGC.GGGC	T.GAGGC.GG
T66058	TC.TCGGCTG	AGCT.GGCCA	TGGCGCANT.	GTTGC.GNGC	T.GAGGC.GG
N57450	TC.TCGGCTG	AGCT.GGCCA	TGGCGCANT.	GGTGC.GGGC	TTGAGGC.GG
N57374	TCCTCGGCTG	AGCT.GGCCA	TGGCGCANT.	GGTGCCGNGC	T.GAGGCCGG
R35464	.....	.....	.....	.....	....GGCCGG
H94519	.....	.....	.....	.....	.....
N39798	.....	.....	.....	.....	.....
H87300	.....	.....	.....	.....	.....
R74593	.....	.....	.....	.....	.....
R31730	.....	.....	.....	.....	.....
R34701	.....	.....	.....	.....	.....
H02982	.....	.....	.....	.....	.....
R32676	.....	.....	.....	.....	.....
T47439	.....	.....	.....	.....	.....
R73968	.....	.....	.....	.....	.....
H39840	.....	.....	.....	.....	.....
H95233	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....
N30199	.....	.....	.....	.....	.....
T52966	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....

Figure 4C (Con't)

	351	400
Bikunin	AC GG CG	TTTTCTCG CC TGCTGGG A TCGCT GC T CCTCTCT
R87894	ACG.	
H16866	AC..CGNCGT	TTTTCTCTCG. CCTTGCTGGG ATTGCGCTGC TTGCTNTCTG
R34808	ACGCGGNCG.	.TTTTTTCGN CCTTGCTGGG ATTGCTTG. TTNCTCTCTN
T66058	...CGGNCG.	.TTTTCTCG. CC.TGCTGGG A.TCGCT.GC T.CCTCTCT.
N57450	ANN.NGCCG.	.TTTCTCG. CC.TGCTGGG A.TCGCT.GC T.CCTCTCT.
N57374	AG..GGCCGG	.TTTCTCG. CCTTGCTGGG A.TCGCT.GC T.CCTCTCTG
R35464	....GTCTG.	.TTTCTCG. CCTGGCTGGG A.TCGCT.GC T.CCTCTCT.
H94519	.GCNGCGCG.	.TTNNTCG. CN.TGCTGGG A.TCGCT.GC A.CCTCTCT.
N39798	.....	....CTGGG ANTGCT.GC T.CCTCTCT.
H87300	.....	.....
R74593	.....	.....
R31730	.....	.....
R34701	.....	.....
H02982	.....	.....
R32676	.....	.....
T47439	.....	.....
R73968	.....	.....
H39840	.....	.....
H95233	.....	.....
H39841	.....	.....
N30199	.....	.....
T52966	.....	.....
N29508	.....	.....
N26919	.....	.....
N26910	.....	.....
H16757	.....	.....
N27732	.....	.....

15/48

Figure 4C (Con't)

	401	450
Bikunin	GGGG TCCTG G CGGCCGA CCGA GAACG CA GCA TCC ACGACTT CT	
H16866	GGGGTTCCTG GG.CGGCCGA CCGA.GAACG CA.GCA.TCC AAGAATTTT	
R34808	GGGGTTC.TG GGGNGGCCGA NCGA.GAACG CAAGCA.TTC ACGA.TTT	
T66058	GGGG.TCCTG G..CGGCCGA CCGA.GAACG CA.GCA.TCC ACGANTT.CT	
N57450	GGGG.TCCTG G..CGGCCGA CCGA.GAACG CA.GCA.TCC ACGACTT.CT	
N57374	GGGG.TCCTG G..CGGCCGA NCGAAGAANG CA.GCAATCC ANGAATTNCT	
R35464	GGGG.TCCTG G.CGGGCCGA CCGA.GAACG CA.GCA.TCC ACGACTT.CT	
H94519	GGGG.TCGNG G..CGGCCGA CCGA.GAACG CA.GCA.TCC ACGACTT.CT	
N39798	GGGG.TCCTG G..CGGCCGA CCGA.GAACG CA.GCA.TCC ACGACTT.CT	
H87300	.....	.....
R74593	.....	.....
R31730	.....	.....
R34701	.....	.....
H02982	.....	.....
R32676	.....	.....
T47439	.....	.....
R73968	.....	.....
H39840	.....	.....
H95223	.....	.....
H39841	.....	.....
N30199	.....	.....
T52966	.....	.....
N29508	.....	.....
N26919	.....	.....
N26910	.....	.....
H16757	.....	.....
N27732	.....	.....

GGGGTTCCTG

1876
 1877
 1878
 1879
 1880
 1881
 1882
 1883
 1884
 1885
 1886
 1887
 1888
 1889
 1890
 1891
 1892
 1893
 1894
 1895
 1896
 1897
 1898
 1899
 1900
 1901
 1902
 1903
 1904
 1905
 1906
 1907
 1908
 1909
 1910
 1911
 1912
 1913
 1914
 1915
 1916
 1917
 1918
 1919
 1920
 1921
 1922
 1923
 1924
 1925
 1926
 1927
 1928
 1929
 1930
 1931
 1932
 1933
 1934
 1935
 1936
 1937
 1938
 1939
 1940
 1941
 1942
 1943
 1944
 1945
 1946
 1947
 1948
 1949
 1950
 1951
 1952
 1953
 1954
 1955
 1956
 1957
 1958
 1959
 1960
 1961
 1962
 1963
 1964
 1965
 1966
 1967
 1968
 1969
 1970
 1971
 1972
 1973
 1974
 1975
 1976
 1977
 1978
 1979
 1980
 1981
 1982
 1983
 1984
 1985
 1986
 1987
 1988
 1989
 1990
 1991
 1992
 1993
 1994
 1995
 1996
 1997
 1998
 1999
 2000
 2001
 2002
 2003
 2004
 2005
 2006
 2007
 2008
 2009
 2010
 2011
 2012
 2013
 2014
 2015
 2016
 2017
 2018
 2019
 2020
 2021
 2022
 2023
 2024
 2025
 2026
 2027
 2028
 2029
 2030
 2031
 2032
 2033
 2034
 2035
 2036
 2037
 2038
 2039
 2040
 2041
 2042
 2043
 2044
 2045
 2046
 2047
 2048
 2049
 2050
 2051
 2052
 2053
 2054
 2055
 2056
 2057
 2058
 2059
 2060
 2061
 2062
 2063
 2064
 2065
 2066
 2067
 2068
 2069
 2070
 2071
 2072
 2073
 2074
 2075
 2076
 2077
 2078
 2079
 2080
 2081
 2082
 2083
 2084
 2085
 2086
 2087
 2088
 2089
 2090
 2091
 2092
 2093
 2094
 2095
 2096
 2097
 2098
 2099
 2100
 2101
 2102
 2103
 2104
 2105
 2106
 2107
 2108
 2109
 2110
 2111
 2112
 2113
 2114
 2115
 2116
 2117
 2118
 2119
 2120
 2121
 2122
 2123
 2124
 2125
 2126
 2127
 2128
 2129
 2130
 2131
 2132
 2133
 2134
 2135
 2136
 2137
 2138
 2139
 2140
 2141
 2142
 2143
 2144
 2145
 2146
 2147
 2148
 2149
 2150
 2151
 2152
 2153
 2154
 2155
 2156
 2157
 2158
 2159
 2160
 2161
 2162
 2163
 2164
 2165
 2166
 2167
 2168
 2169
 2170
 2171
 2172
 2173
 2174
 2175
 2176
 2177
 2178
 2179
 2180
 2181
 2182
 2183
 2184
 2185
 2186
 2187
 2188
 2189
 2190
 2191
 2192
 2193
 2194
 2195
 2196
 2197
 2198
 2199
 2200
 2201
 2202
 2203
 2204
 2205
 2206
 2207
 2208
 2209
 2210
 2211
 2212
 2213
 2214
 2215
 2216
 2217
 2218
 2219
 2220
 2221
 2222
 2223
 2224
 2225
 2226
 2227
 2228
 2229
 2230
 2231
 2232
 2233
 2234
 2235
 2236
 2237
 2238
 2239
 2240
 2241
 2242
 2243
 2244
 2245
 2246
 2247
 2248
 2249
 2250
 2251
 2252
 2253
 2254
 2255
 2256
 2257
 2258
 2259
 2260
 2261
 2262
 2263
 2264
 2265
 2266
 2267
 2268
 2269
 2270
 2271
 2272
 2273
 2274
 2275
 2276
 2277
 2278
 2279
 2280
 2281
 2282
 2283
 2284
 2285
 2286
 2287
 2288
 2289
 2290
 2291
 2292
 2293
 2294
 2295
 2296
 2297
 2298
 2299
 2300
 2301
 2302
 2303
 2304
 2305
 2306
 2307
 2308
 2309
 2310
 2311
 2312
 2313
 2314
 2315
 2316
 2317
 2318
 2319
 2320
 2321
 2322
 2323
 2324
 2325
 2326
 2327
 2328
 2329
 2330

	451	500
Bikunin	GCCTGGTGT CGAAGGT GG TGGGCAGATG CCGGG CCTC CATGCCTA G	
H16866	GCC	
T66058	TCCTGGTGT CGAAGG	
N57450	GCCTGGTGT. CGAAGGT.GG TGGGCAG	
N57374	GCCTGGTGT CGAAGGTGG TGGGCANATT CCGGGGCCCTT CATGNCTAAG	
R35464	GCCTGGTGT. CGAAGGT.GG TGGGCAGATT CCGGG.CCTC CATGCCTA.G	
H94519	GCCTGGTGT. CGAAGGT.GG TGGGCAGATG CCGGG.CCTC CATGCCTA.G	
N39798	GCCTGGTGT. CGAAGGT.GG TGGGCAGATG CCGGG.CCTC CATGCCTA.G	
H87300	
R74593	
R31730	
R34701	
H02982	
R32676	
T47439	
R71968	
H39840	
H95233	
H39841	
N30199	
T52966	
N29508	
N26919	
N26910	
H16757	
N27732	

17/48

Figure 4C (Con't)

	501				550
Bikunin	G TGGT GGT	ACAATGTCAC	TGACGGATCC	TGCCAGCTGT	TTGTGT ATG
N57374	GTTCGTGGT	ANAATGTNAA	TTAANGATTC	TTGCAACTGT	TTGTGTNAAT
R35464	G.TGGT.GGT	ACAATGTCAC	TGACGGATCC	TGCCAGCTGT	TTGTGT.ATG
H94519	G.TGGT.GGT	ACAATGTCAC	TGACGGATCC	TGCCAGCTGT	TTGTGT.ATG
N39798	G.TGGT.GGT	ACAATGTCAC	TGACGGATCC	TGCCAGCTGT	TTGTGT.ATG
H87300	.....	.....	.....	.....	.....
R74593	.....	.....	.....	.....	.....
R31730	.....	.....	.....	.....	.....
R34701	.....	.....	.....	.....	.....
H02982	.....	.....	.....	.....	.....
R32676	.....	.....	.....	.....	.....
T47439	.....	.....	.....	.....	.....
R73968	.....	.....	.....	.....	.....
H39840	.....	.....	.....	.....	.....
H95233	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....
N30199	.....	.....	.....	.....	.....
T52966	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....

	551				600
Bikunin	GGGGCTGTGA	CGGAAACA	GCAATAATTA	CCTGACCAAG	GA GGAGTGC
N57374	GGGGCTNTTA	AACGGAAANA	.CAATAATNA	CCTGACCAAA	GAAGNAAT..
R35464	GGGGCTGTGA	..CGGAAACA	GCAATAATTA	CCTGACCAAG	GA.GGAGTGC
H94519	GGGGCTGTGA	..CGGAAACA	GCAATAATTA	CCTGACCAAG	GA.GGAGTGC
N39798	GGGGCTGTGA	..CGGAAACA	GCAATAATTA	CCTGACCAAG	GA.GGAGTGC
H87300	GATTCGGCAC	AGGGGAAACA	GCAATAATTA	CCTGACCAAG	GA.GGAGTNC
R74593	.....	.....	GCAATAATTA	CCTGACCAAG	GA.GGAGTGC
R31730	.....	.....	.....	.....	.....
R34701	.....	.....	.....	.....	.....
H02982	.....	.....	.....	.....	.....
R32676	.....	.....	.....	.....	.....
T47439	.....	.....	.....	.....	.....
R73968	.....	.....	.....	.....	.....
H39840	.....	.....	.....	.....	.....
H95233	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....
N30199	.....	.....	.....	.....	.....
T52966	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....

Bikunin cDNA

12/48

Figure 4C (Con't)

	601				650
Bikunin	CTCAAGAAAT	GTGCCACTGT	CACAGAGAAT	GCCACGGGTG	ACCTGGCCAC
R35464	CTCAAGAAAT	GTGCCACTGT	CACAGAGAAT	GCCACGGGTG	ACCTGGCCAC
H94519	CTCAAGAAAT	GTGCCACTGT	CACAGAGAAT	GCCACGGGTG	ACCTGGCCAC
N39798	CTCAAGAAAT	GTGCCACTGT	CACAGAGAAT	GCCACGGGTG	ACCTGGCCAC
H87300	CTCAAGAAAT	GTGCCACTGT	CACAGAGAAT	GCCACGGGTG	ACCTGGCCAC
R74593	CTCAAGAAAT	GTGCCACTGT	CACAGAGAAT	GCCACGGGTG	ACCTGGCCAC
R31730	.....	.....	.....	.....	.....
R34701	.....	.....	.....	.....	.....
H02982	.....	.....	.....	.....	.....
R32676	.....	.....	.....	.....	.....
T47439	.....	.....	.....	.....	.....
R73968	.....	.....	.....	.....	.....
H39840	.....	.....	.....	.....	.....
H95233	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....
N30199	.....	.....	.....	.....	.....
T52966	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....
	651				700
Bikunin	CAGCAGGAAT	GCAGCGGATT	CCTCTGTCCC	AAGTGCTCCC	AGAAGGCAGG
R35464	CAGCAGGAAT	GCAGCGGATT	CCTCTGTCCC	AAGTGCTCCC	AGAAGGCAGG
H94519	CAGCAGGAAT	GCAGCGGATT	CCTCTGTCCC	AAGTGCTCCC	AGAAGGCAGG
N39798	CAGCAGGAAT	GCAGCGGATT	CCTCTGTCCC	AAGTGCTCCC	AGAAGGCAGG
H87300	CAGCAGGAAT	GCAGCGGATT	CCTCTGTCCC	AAGTGCTCCC	AGAAGGCAGG
R74593	CAGCAGGAAT	GCAGCGGATT	CCTCTGTCCC	AAGT.CTCCC	AGAAGGCAGG
R31730	.....	.....	.....	.....	.....
R34701	.....	.....	.....	.....	.....
H02982	.....	.....	.....	.....	.....
R32676	.....	.....	.....	.....	.....
T47439	.....	.....	.....	.....	.....
R73968	.....	.....	.....	.....	.....
H39840	.....	.....	.....	.....	.....
H95233	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....
N30199	.....	.....	.....	.....	.....
T52966	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....

Bikunin "ETFE"

[illegible]

Figure 4C (Con't)

	701	750
Bikunin	ATTCT GAAG ACCACTCCAG CGATATGTT CAACTAT G AAGAATACTG	
R35464	ATTCTTGAAG ACCACTTCAG CGATATGTTT CAANTATTGN AAGAATAATT	
H94519	ATTCT.GAAG ACCACTCCAG CGATATGTT. CAACTAT..G AAGAATACTG	
N39798	ATTCT.GAAG ACCACTCCAG CGATATGTT. CAACTAT..G AAGAATACTG	
H87300	ATTCT.GAAG ACCACTCCAG CGATATGTT. CAACTAT..G AAGAATACTG	
R74593	ATTCT.GAAG ACCACTCCAG CGATATGTT. CAACTAT..G AAGAATACTG	
R31730	.....
R34701	.....
H02982	.....
R32676	.....
T47439	.....
R73968	.....
H39840	.....
H95233	.....
H39841	.....
N30199	.....
T52966	.....
N29508	.....
N26919	.....
N26910	.....
H16757	.....
N27732	.....

	751	800
Bikunin	CACCGCCAA CGCAGT CAC TGGGCC TTG CCGTG CAT CCTT CCCAC	
R35464	GCACCGNCAA CGNATT	
H94519	GCACCGCCAA CGCATT.CAC TGGGCC..TG C.GTG.CAT. CCTT.CCCAC	
N39798	.CACCGCCAA CGCAGT.CAC TGGGGCCTTG C.GTGAAT. CTTTCCAC	
H87300	.CACCGCCAA CGCAGTNCAC TGGGCC.TTG C.GTGGCATN CTTT.CCCAC	
R74593	.CACCGCCAA CGCAGT.CAC TGGGCC.TTG CCGTG.CAT. CCTT.CCCAC	
R31730	.....
R34701	.....
H02982	.....
R32676	.....
T47439	.....
R73968	.....
H39840	.....
H95233	.....
H39841	.....
N30199	.....
T52966	.....
N29508	.....
N26919	.....
N26910	.....
H16757	.....
N27732	.....

20/48

Figure 4C (Con't)

	801		850
Bikunin	GCTGGTACTT	T GACGTGGA GA GGAAGTC CTG CAATAA	CTTCATCTAT
H94519	GCTGGTACTT	T.GNCGT	
N39798	GCTGGNAATT	INGACGTTGA GAAGGAAC	
H87300	GCTNGTACTT	T.GACGTGGA GA.GGAAGTC CTGGCAATAA	CTTCATCTAT
R74593	GCTGGTACTT	T.GACGTGGA GA.GGAAGTC CTG.CAATAA	CTTCATCTAT
R31730	.....	.....	.....
R34701	.....	.....	.....
H02982	.....	GA GA.GGAAGTC CTG.CAATAA	CTTCATCTAT
R32676	.....	.....	G ATTC..GGAA
T47439	.....	.....	.....
R73968	.....	.....	.....
H39840	.....	.....	.....
H95233	.....	.....	.....
H39841	.....	.....	.....
N30199	.....	.....	.....
T52966	.....	.....	.....
N29508	.....	.....	.....
N26919	.....	.....	.....
N26910	.....	.....	.....
H16757	.....	.....	.....
N27732	.....	.....	.....

	851		900
Bikunin	GGAGGCT GC	CGGGGCAAT AAGAACAG C	TACCGCTC T GAGGAGGCCT
H87300	GGAGGCTTGC	CGGGGCAATN AAGAACAGNT	TACCGCTCTT TAGGAGGCCT
R74593	GGAGGCT.GC	CGGGGCAAT. AAGAACAG.C	TACCGCTC.T GAGGAGGCCT
R31730	.....	.....G.C	TACCGCTC.T GAGGAGGCCT
R34701	.....	.....	.....
H02982	GGNGGCT.GC	CGGGG.AAT. AAGAACA.NC	TACCGCTC.T GAGGAGGCCT
R32676	CGAGGA..GC	CGGGGCAAT. AAGAACAG.C	TACCGCTC.T GAGGAGGCCT
T47439	.....	.....	.....NGGCCT
R73968	.....	.....	.....
H39840	.....	.....	.....
H95233	.....	.....	.....
H39841	.....	.....	.....
N30199	.....	.....	.....
T52966	.....	.....	.....
N29508	.....	.....	.....
N26919	.....	.....	.....
N26910	.....	.....	.....
H16757	.....	.....	.....
N27732	.....	.....	.....

Bikunin "ETFE" 260

21/48

Figure 4C (Con't)

	901	950
Bikunin	GCA TGCTC CGCTGCTTCC GC	CA GCAGGA
H87300	.GCA.T....	
R74593	.GCA.TGCTC CGCTGCTTCC GC.....	.CA.GCAGGA
R31730	.GCA.TGCTC CGCTGCTTCC GC.....	.CA.GCAGGA
R34701	.....TTCC GC.....	.CAAGCAGGA
H02982	.GCG.TGCTC CGCTGCTTCC GCTGTGTGTT CTCTTCCAGG	CCA.GCAGGA
R32676	.GCA.TGCTC CGCTGCTTCC GC.....	.CA.GCAGGA
T47439	TGCAGTGCTC CGCTGCTTCC GC.....	.CA.GCAGGA
R73968	.....
H39840	.....
H95233	.....
H39841	.....
N30199	.....
T52966	.....
N29508	.....
N26919	.....
N26910	.....
H16757	.....
N27732	.....
	951	1000
Bikunin	GAA TCCTCC CCTGCCCCCTT GGCTCAAAGG TGGTGGTTC	TGG CGGGGC
R74593	GAA.TCCTCC CCTGCCCCCTT GGCTCAAAGG TGGTGGTTC.	TGGCGGGGC
R31730	GAA.TCCTCC CCTGCCCCCTT GGCTCAAAGG TGGTGGTTC.	TGG.CGGGGC
R34701	AAANTCCTCC CCTCCCCCTT GGCTCAAAGG TGGTGGTTC	TGG.CGGGGC
H02982	GAA.TCCTCC CCTGCCCCCTT GGCTCAAAGG TGGTGGTTC.	TGG.CGGGGC
R32676	GAA.TCCTCC CCTGCCCCCTT GGCTCAAAGG TGGTGGTTC.	TGG.CGGGGC
T47439	GAA.TCCTCC CCTGCCCCCTT GGCTCAAAGG TGGTGGTTC.	TGG.CGGGGC
R73968	.....	....CGGGGC
H39840	.....
H95233	.....
H39841	.....
N30199	.....
T52966	.....
N29508	.....
N26919	.....
N26910	.....
H16757	.....
N27732	.....

Bikunin: CTTCTG

27/48

Figure 4C (Con't)

	1001				1053
Bikunin	TGTT CGTGA	TGGTGTTCAT	CC T CTTC	TGGG AGCCT	CC ATGGTC
R74593	TGTTTCGTGA	TGGTGTTCAT	CCTT..TTCC	TGGGGAGCCT	CC.ATGGTCT
R31730	TGTT.CGTGA	TGGTGTTCAT	CC.T.CTTC	TGGGGAGCCT	CC.ATGGTC.
R34701	TGTT.CGTGA	TGGTGTTCAT	CCCTCCCTTC	CGGG.AGCCT	CCCATGGTCC
H02982	TGTT.CGTGA	TGGTGTTCAT	CC.T.CTTC	TGGG.AGCCT	CC.ATGGTN.
R32676	TGTT.CGTGA	TGGTGTTCAT	CC.T.CTTC	TGGG.AGCCT	CC.ATGGTC.
T47439	TGTT.CGTGA	TGGTGTTCAT	CC.T.CTTC	TGGG.AGCCT	CC.ATGGTC.
R73968	TGTT.CGTGA	TGGTGTTCAT	CC.T.CTTC	TGGG.AGCCT	CC.ATGGTC.
H39840	.....	.....	.....	.....	.....
H95233	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....
N30199	.....	.....	.....	.....	.....
T52966	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....

	1051				1100
Bikunin	TACC TGAT	CCGGGTGGCA	CGGAGG AAC	C AGG AGCG	TGCCCTGCCG
R74593	TAC..TGAT	CCGGGTGGCA	AGGAGG.AAC	C.AGG.AGCG	TGCCCTGCCG
R31730	TACC.TGAT.	CCGGGTGGCA	CGGAGGGAAC	C.AGGGAGCG	TGCCCTGCCG
R34701	TACCCTGAT.	CCGGGTGGCA	CGGAGG.AAC	CCAGG.ANCG	TGCCCTGCCG
H02982	TACC.TGAT.	CCGGGTNGCA	CGGAGG.AAC	C.AGGGAGCG	TGCCCTGCCG
R32676	TACC.TGAT.	CCGGGTGGCA	CGGAGG.AAC	C.AGGGAGCG	TGCCCTGCCG
T47439	TACC.TGAT.	CCGGGTNGCA	CGGAGG.AAC	C.AGG.AGCG	TGCCCTGCCG
R73968	TACC.TGAT.	CCGGGTGGCA	CGGAGG.AAC	C.AGG.AGCG	TGCCCTGCCG
H39840	.....	.....	...GGG.AAC	C.AGG.AGCG	TGCCCTGCCG
H95233	.....	.....	.....	.....	.....
H39841	.....	.....	.....	.....	.....
N30199	.....	.....	..GAGGAACC	C.ANG.AGCT	TGCCCTGCCG
T52966	.....	.....	.....	.....	.....
N29508	.....	.....	.....	.....	.....
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....

Bikunin " E T G T G C G C

[illegible]

Figure 4C (Con't)

	1101	1150
Bikunin	ACCG TCT G GAGCTCCGGA GATGACAAGG AGCAGCTGG TGAAGAAC	
R74593	ANCG.TCT.G GAGCTCCGGA GATGACAAGG GNT	
R31730	ACCG.TCTGG GAGCTCCGGA GATGACAAGG GAGCAGCTGG GTGAAGAAC.	
R34701	ACCG.TCT.G GAGCTCCGGA GATGACAAGG .AGCAGCTGG .TGAAGAAC.	
H02982	ACCG.TCTNG GAGCTCCGGA GATGACAAGG .AGCAGCTGG .TGAAGAAC.	
R32676	ACCG.TCTGG GAGCTCCGGA GATGACAAGG GAGCAGCTGG .TGAAGAAC.	
T47439	ACCG.TCT.G GAGCTCCGGA GATGACAAGG .AGCAGCTGG .TGAAGAAC.	
R73968	ACCG.TCT.G GAGCTCCGGA GATGACAAGG .AGCAGCTGG .TGAAGAAC.	
R39840	ACCGGTCT.G GAGCTCCGGA GATGACAAGG .AGCAGCTGG .TGAAGAAC.	
H95233	.....
H39841	.....
N30199	ACCG.TCT.G GAGCTCCGGA GATNACAANG .AGCAGCTGN .TGAAGAACC	
T52966	.....
N29508	.....
N26919	.....
N26910	.....
H16757	.....
N27732	.....

	1151				1200
Bikunin	ACATATGT.C	CTGT.GACCG	CCCTGT.CGC	C.AAGAGG.A	CT.GGGGAA
R31730	ACATATGTTT	CTGTTGACCG	NCCTGTTCCG	C.AAGAGG.A	TGGGGGGAA.
R34701	ACATATGT.C	CTGT.GACCG	CCCTGT.CGC	C.AAGAGG.A	CT.GGGGAA.
H02982	ACATATGT.C	CTGT.GACCG	NCCTGTTCCG	C.AAGAGG.A	CTNGGGGGAAA
R32676	ACATATGTTT	CTGTTGACCG	CCCTGTTCCG	C.AAGAGGGA	NTGGGGGGAA.
T47439	ACATATGT.C	CTGT.GACCG	CCCTGT.CGC	C.AAGAGG.A	CT.GGGGAA.
R73968	ACATATGT.C	CTGT.GACCG	CCCTGT.CGC	C.AAGAGG.A	CT.GGGGAA.
H39840	ACATATGT.C	CTGT.GACCG	CCCTGT.CGC	C.AAGAGG.A	CT.NGGGAA.
H95233	.....	.....	.....	.....	.....
H39841	.....	.....C.	CCCTGT.CGC	CCAAAAGG.A	CT.GGGGAA.
N30199	ACATATGT.C	CTGT.GACCG	CCCTNT.CGC	C.AAGAGG.A	CT.GGGNAAA
T52966	.....	.....	.....	.....	.....
N29508	.....	.....CC.	CCCTNT.CGC	C.AAGAGG.A	CT.GGG.AA.
N26919	.....	.....	.....	.....	.....
N26910	.....	.....	.....	.....	.....
H16757	.....	.....	.....	.....	.....
N27732	.....	.....	.....	.....	.....

[illegible]

Figure 4C (Con't)

	1201								1250
Bikunin	GGGAGGGG	AGACTAT G	TGT GA GCT	TTTTTT	AA A TAGA	GG			
R31730	.GGGAGGGGG	A							
R34701	.GGGAGGGG.	AGACTAT.G.	TGT.GA.GCT	TTTTTT..AA	A.TA				
H02982	GGGGAGGGG.	AGATTAT.G.	TGTTGA.GTT	TTTTTT..AA	ANTAG				
R32676	GGGGAGGGGG	AGANTATTGT	TGTTGA.GNT	TTTTTTTAAA	ATTAGGAGGG				
T47439	.GGGAGGGG.	AGACTAT.G.	TGT.GA.GCT	TTTTTT..AA	A.TAGA..GG				
R73968	.GGGAGGGG.	AGACTAT.G.	TGT.GA.GCT	TTTTTT..AA	A.TAGA..GG				
H39840	.GGGAGGGG.	AGACTAT.G.	TGT.GA.GCT	TTTTTT..AA	A.TAGA..GG				
H95233	.....							
H39841	.GGGAGGGGA	AAACNAT.G.	TGT.GAACCT	TTTTTT.AAA	A.TAGA..GG				
N30199	.GGGAGGNG.	AGACTAT.G.	TGT.AA.GCT	TTTTTT..AA	A.TAGA..GG				
T52966	.....							
N29508	.GGGAGGGG.	AGACTA..G.	TGT.GA.GCT	TTTTTT..AA	A.TAGA..GG				
N26919	.....							
N26910	.....							
H16757	.....							
N27732	.....							

	1251		1300
Bikuria	GATTGACTC	GGATTTC A GT GATC A	TTAGGG CT GAGGTCTGTT
R32676	GNTTGANTTC	GGGNTTTTNA GTTGATCCAT	TTAGGGGGNT GAG
T47439	GATTGACTC.	..GGATTTC.A GT.GATC.A.	TTAGGG..CT GAGGTCTNTT
R73968	GATTGACTC.	..GGATTTC.A GT.GATC.A.	TTAGGG..CT GAGGTCTGTT
H39840	GATTGACTC.	..GGATTTC.A GT.GATC.A.	TTAGGG..CT GAGGTCTGTT
H95233	.....	.....A.	TTAGGG..CT GAGGTCTGTT
H39841	GATTGACTC.	..GGATTTC.A GT.GATC.A.	TTAGGG..CT GAGGTCTGTT
N30199	GATTGACTC.	..GGATTTGA GT.GATC.A.	TTAGGG..CT GAGGTCTGTT
T52966	.....	.....	.....
N29508	GATTGACTC.	..GGATTTC.A GT.GATCNA.	TTAGGG..CT GAGGTCTGTT
N26919	.....	.....	.....
N26910	.....	.....	.....
H16757	.....	.....	.....
N27732	.....	.....	.....

	1301		1350
Bikurin	TCTCTGGGAG GTAGGACGGC	TGCTTCC TC G TC TGGCA	GGGATGGG
T47439	TCTCTNGGAG GTAGGACGA		
R73968	TCTCTGGGAG GTAGGACGGC	TGCTTCC TC GGTCTTGGCA	GGGATGGGG
H39840	TCTCTGGGAG GTAGGACGGC	TGCTTCC TC G TC TGGCA	GGGATGGG.
H95233	NCTCTGGGAG NTAGGACGGC	TGCTTCC TC G TC TGGCA	GGGATGGG.
H39841	TNCTCTGGGAG GTAGGACGGC	TGCTTCC TC G TC TGGCA	GGGATGGG.
N30199	TCTCTGGGAG GTAGGACGGC	TGCTTCC TC G TC TGGCA	GGGATGGG.
T52966	.....	..... TC TGGCA	GGGATGGG.
N29508	TCTCTGGGAG GTAGGACGGC	TGCTTCA TC G TC TGGCA	GGGATGGG
N26919	.....	.....	.....
N26910	.....	.....	.....
H16757	.....	..... G TC TGGCA	GGGATGGG.
N27732	.....	..... CCCTG GGTCTTGNCA	AGGNATGGGG

[illegible]

Figure 4C (Con't)

[illegible]

	1401	1450
Bikunin	CAGT CT GG CAGCAG CCC CGAGTTGTTT	CC TCGCTG ATC GATTTC
R73968	CAGT.CTNGG CAGCANCCCC CGAGTTTTTT	TCCTCGCTG ATCCGATTTC
H39840	CAGT.CT.GG CAGCAG.CCC CGAGTTGTTT	.CC.TCGCTG ATC.GATTTC
H95233	CAGTTCT..G CAGCAG.CCC CGAGTTGTTT	.CC.TCGCTG ATC.GATTTC
H39841	CAGT.CT.GG CAGCAG.CCC CGAGTTGTTN	.CC.TCGCTG ATC.GATTTC
N30199	CAGT.CT.GG CAGCAG.CCC CGAGTTGTTT	.CC.TCGCTG ATC.GATTTC
T52966	CAGT.CT.GG CAGCAG..CC CGAGTTGTTT	.CC.TCGCTG ATC.GATTTC
N29508	CAGT.CT..G CAGCAG.CCC CGAGTTGTTT	.CC.TCGCTG ATC.GATTTC
N26919	CAGT.CTTGG CAGCAG.CCC CGAGTTGTTT	.CC.TCGCTG ANC.GATTTC
N26910	CAGT.CT..G CAGCAG.CCC CGAGTTGTTT	.CC.TCGCTG ATCGGATTTC
H16757	CAGTNCT.GG CAGCAGACCC CGAGTTGTTT	.CC.TCGCTG ATC.GATTTC
N27732	CAGT.CT.GG CAGCAG.CCC CGAGTTGTTT	.CC.TCGCTG ANC.GATTTC

	1451	1500
Bikunin	TTT CCTCCA GGTAG AGT TTTC TTTC	CTTATGTTGA ATTCGATTGC
R73968	TTTTCTCTCCA GGTAAAGAATT	TTTCTTTT
H39840	TTT.CCTCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC
H95233	TTT.CCTCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC
H39841	TTT.CCCCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC
N30199	TTT.CCTCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC
T52966	TTT.CCTCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC
N29508	TTT.CCTCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC
N26919	TTT.CCNCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC
N26910	TTT.CCTCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC
H16757	TTTACCCCCA GGTAG..AGT TTTCCTTTGN	CTTATGTTGA ATTCGATTGC
N27732	TTT.CCTCCA GGTAG..AGT TTTC.TTTC.	CTTATGTTGA ATTCGATTGC

26/46

Figure 4C (Con't)

1501 1550

Bikunin CTCTTTT CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT GT
H39840 CTCTTTT.CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTTGT
H95233 CTCTTTT.CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT
H39841 CTCTTTT.CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT
N30199 CTCTTTT.CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT
T52966 CTCTTTT.CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT
N29508 CTCTTTT.CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT
N26919 CTCTTTT.CN CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT
N26910 CTCTTTT.CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT
H16757 CTCTTTTACT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT
N27732 CTCTTTT.CT CATCACAGAA GTGATGTTGG AATCGTTTCT TTTGTTT.GT

1551 1600

Bikunin CTGATTTATG G TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
H39840 CTGATTTATG GGTTTTTTTT AAGTAT
H95233 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
H39841 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
N30199 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
T52966 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
N29508 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
N26919 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
N26910 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
H16757 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT
N27732 CTGATTTATG G..TTTTTT AAGTATAAAC AAAAGTTTTT TATTAGCATT

1601 1650

Bikunin CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAAAAG GGGCCTTCCC
H95233 CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAA
H39841 CTGAAAGAAG GAAAGTAAAN TGTACAAGTT TAATAAAAAG GGGCCTTCCC
N30199 CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAAAAG GGGCCTTCCC
T52966 CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAAAAG GGGCCTTCCC
N29508 CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAAAAG GGGCCTTCCC
N26919 CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAAAAG GGGCCTTCCC
N26910 CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAAAAG GGGCCTTCCC
H16757 CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAAAAG GGGCCTTCCC
N27732 CTGAAAGAAG GAAAGTAAAA TGTACAAGTT TAATAAAAAG GGGCCTTCCC

1651 1689

Bikunin CTTTAG AAT AAAAAAAAAA AAAAAAAAAA AAAAAAAAAA
H39841 CTTTAA.
N30199 CTTTAG.AAT AAA
T52966 CTTTAGGAAT NAAAAHAAAA AAGGGTG
N29508 CTTTAG.AAT AAATTTCAGC ATGTGCTTTC AA
N26919 CTTTAG.AAT AAAAAAAAAA AAAAAAAAAA A
N26910 CTTTAG.AAT AAATTTCAGC ATGTGCTTTC AAAAAA
H16757 CTTTAG.AAT AAAAAAAAAA AAAAAAAAAA AAAAAA
N27732 CTTTAG.AAT AAAAAAAAAA AAAAAAAAAA AAAAAAAAAA

Bikunin "E" 66T250

FIGURE 4D

27/48

EST consensus MLRAEADGVS RLLGSULLSG VLAADRERSI HDFCLVSKVV GRCRASMPRW 50
EST consensus WYNVTDGSCQ LFVYGGCDGN SNNYLTKEEC LKRCATVTEN ATGDLATSRN 100
EST consensus AADSSVPSAP RRQDSEDHSS DMFNYEEYCT ANAVTGPCRA SFPRWYFDVE 150
EST consensus RNSCNNFIYG GCRGNKNSYR SEEACMLRCF RQENPPLPL GSKVYVLAGL 200
EST consensus FVMVLILFLG ASMXYLIRVA RRNQERALRT VWSSGDDKEQ LVKNITYVL 248

EST consensus

FIGURE 4E

28/48

cDNA		ACC	3
translation		T	-47
cDNA	TGATCGCGAG ACCCCAACGG CTGGTGGCGT CGCCTGCGCG TCTCGGCTGA	53	
translation	S R D P N G W W R R L R V S A E	-30	
cDNA	GCTGGCCATG GCGCAGCTGT GCGGGCTGAG GCGGAGCCGG GCGTTTCTCG	103	
translation	L A M A Q L C G L R R S R A F L A	-13	
cDNA	CCCTGCTGGG ATCGCTGCTC CTCTCTGGGG TCCTGGCGGC CGACCGAGAA	153	
translation	L L G S L L L S G V L A A D R E	4	
cDNA	CGCAGCATCC ACGACTTCTG CCTGGTGTCTG AAGGTGGTGG GCAGATGCCG	203	
translation	R S I H D F C L V S K V V G R C R	21	
cDNA	GGCCTCCATG CCTAGGTGGT GGTACAATGT CACTGACGGA TCCTGCCAGC	253	
translation	A S M P R W W Y N V T D G S C Q L	38	
cDNA	TGTTTGTGTA TGGGGGCTGT GACGGAAACA GCAATAATTA CCTGACCAAG	303	
translation	F V Y G G C D G N S N N Y L T K	54	
cDNA	GAGGAGTGCC TCAAGAAATG TGCCACTGTC ACAGAGAATG CCACGGGTGA	353	
translation	E E C L K K C A T V T E N A T G D	71	
cDNA	CCTGGCCACC AGCAGGAATG CAGCGGATTC CTCTGTCCCA AGTGCTCCCA	403	
translation	L A T S R N A A D S S V P S A P R	88	
cDNA	GAAGGCAGGA TTCTGAAGAC CACTCCAGCG ATATGTTCAA CTATGAAGAA	453	
translation	R Q D S E D H S S D M F N Y E E	104	
cDNA	TACTGCACCG CCAACGCAGT CACTGGGCCT TGCCGTGCAT CCTTCCCACG	503	
translation	Y C T A N A V T G P C R A S F P R	121	
cDNA	CTGGTACTTT GACGTGGAGA GGAACCTCTG CAATAACTTC ATCTATGGAG	553	
translation	W Y F D V E R N S C N N F I Y G G	138	
cDNA	GCTGCCGGGG CAATAAGAAC AGCTACCGCT CTGAGGAGGC CTGCATGCTC	603	
translation	C R G N K N S Y R S E E A C M L	154	
cDNA	CGCTGCTTCC GCCAGCAGGA GAATCCTCCC CTGCCCCTTG GCTCAAAGGT	653	
translation	R C F R Q Q E N P P L P L G S K Y	171	
cDNA	GGTGGTTCTG GCGGGGCTGT TCGTGATGGT GTTGATCCTC TTCCTGGGAG	703	
translation	<u>V V L A G L F V M V L L L F L G A</u>	188	
cDNA	CCTCCATGGT CTACCTGATC CGGGTGGCAC GGAGGAACCA GGAGCGTGCC	753	
translation	<u>S M V Y L L</u> R V A R R N Q E R A	204	
cDNA	CTGCGCACCG TCTGGAGCTT CGGAGATGA	782	
translation	L R T V W S F G D	213	

094434-1

FIGURE 4F

29/48

cDNA GCACGAGTTG GGAGGTGTAG CGCGGCTCTG AACGCGCTGA GGGCCGTTGA 50
 cDNA GTGTGCGCAGG CGGCGAGGGC GCGAGTGAGG AGCAGACCCA GGCATCGCGC 100
 cDNA GCCGAGAAGG CCGGGCGTCC CCACACTGAA GGTCCGGAAG GCGACTTCC 150
 cDNA GGGGGCTTTG GCACCTGGCG GACCCTCCCG GAGCGTCGGC ACCTGAACGC 200
 cDNA GAGGCGCTCC ATTGCGCGTG CGCGTTGAGG GGCTTCCCGC ACCTGATCGC 250
 cDNA GAGACCCCAA CGGCTGGTGG CGTCGCTGC GCGTCTCGGC TGAGCTGGCC 300
 cDNA ATGGCGCAGC TGTGCGGGCT GAGGCGGAGC CGGGCGTTTC TCGCCCTGCT 350
 translation M A Q L C G L R R S R A F L A L L -11

cDNA GGGATCGCTG CTCCTCTCTG GGGTCCTGGC GGCCGACCGA GAACGCAGCA 400
 translation G S L L L S G V L A A D R E R S I 7

cDNA TCCACGACTT CTGCCTGGTG TCGAAGGTGG TGGGCAGATG CCGGGCCTCC 450
 translation H D F C L V S K V V G R C R A S 23

cDNA ATGCCTAGGT GGTGGTACAA TGTCACTGAC GGATCCTGCC AGCTGTTTGT 500
 translation M P R W W Y N V T D G S C Q L F V 40

cDNA GTATGGGGGC TGTGACGGAA ACAGCAATAA TTACCTGACC AAGGAGGAGT 550
 translation Y G G C D G N S N N Y L T K E E C 57

cDNA GCCTCAAGAA ATGTGCCACT GTCACAGAGA ATGCCACGGG TGACCTGGCC 600
 translation L K K C A T V T E N A T G D L A 73

cDNA ACCAGCAGGA ATGCAGCGGA TTCCTCTGTC CCAAGTGCTC CCAGAAGGCA 650
 translation T S R N A A D S S V P S A P R R Q 90

cDNA GGATTCTGAA GACCACTCCA GCGATATGTT CAACTATGAA GAATACTGCA 700
 translation D S E D H S S D M F N Y E E Y C T 107

cDNA CCGCCAACGC AGTCACTGGG CTTTGCCGTG CATCCTTCCC ACGCTGGTAC 750
 translation A N A V T G P C R A S F P R W Y 123

cDNA TTTGACGTGG AGAGGAATC CTGCAATAAC TTCATCTATG GAGGCTGCCG 800
 translation F D V E R N S C N N F I Y G G C R 140

cDNA GGGCAATAAG AACAGCTACC GCTCTGAGGA GGCCTGCATG CTCCGCTGCT 850
 translation G N K N S Y R S E E A C M L R C F 157

cDNA TCCGCCAGCA GGAGAATCCT CCCCTGCCCC TTGGCTCAAA GGTGGTGGTT 900
 translation R Q Q E N P P L P L G S K V V V 173

cDNA CTGGCGGGGC TGTTCGTGAT GGTGTTGATC CTCTTCCTGG GAGCCTCCAT 950
 translation L A G L F V M V L L L F L G A S M 190

cDNA GGTCTACCTG ATCCGGGTGG CACGGAGGAA CCAGGAGCGT GCCCTGCGCA 1000
 translation V Y L I R V A R R N Q E R A L R T 207

cDNA CCGTCTGGAG CTCCGGAGAT GACAAGGAGC AGCTGGTGAA GAACACATAT 1050
 translation V W S S G D D K E Q L V K N T Y 223

cDNA GTCCTGTGAC CGCCCTGTGG CCAAGAGGAC TGGGGAAGGG AGGGGAGACT 1100
 translation V L * 225

0921851-13293

FIGURE 4F (Con't)

30/48

cDNA	ATGTGTGAGC	TTTTTTTAAA	TAGAGGGATT	GACTCGGATT	TGAGTGATCA	1150
cDNA	TTAGGGCTGA	GGTCTGTTTC	TCTGGGAGGT	AGGACGGCTG	CTTCCTGGTC	1200
cDNA	TGGCAGGGAT	GGGTTTGCTT	TGGAAATCCT	CTAGGAGGCT	CCTCCTCGCA	1250
cDNA	TGGCCTGCAG	TCTGGCAGCA	GCCCCGAGTT	GTTTCCTCGC	TGATCGATTT	1300
cDNA	CTTTCCTCCA	GGTAGAGTTT	TCTTTGCTTA	TGTTGAATTC	CATTGCCTCC	1350
cDNA	TTTTCTCNAT	CACAGAAGTG	ATGTTGGAAT	CGTTTCTTTT	GTTTGTCTGA	1400
cDNA	TTTATGGTTT	TTTAAGTAT	AAACAAAAGT	TTTTTATTAG	CATTCTGAAA	1450
cDNA	GAAGGAAAGT	AAAATGTACA	AGTTTAATAA	AAAGGGGCCT	TCCCCTTTAG	1500
cDNA	AATAAATTC	CAGCATGTTG	CTTTCAAAAA	AAAAAAAAAA	AAAA	

1550

B63447-16-6-26-60

31/48

EST consens			MLR	AEADGVSRL	GSLLLSGVLA	-1
PCR clone			MAQLCGL	RRSRAFLAL	GSLLLSGVLA	-1
λcDNA clone			MAQLCGL	RRSRAFLAL	GSLLLSGVLA	-1
EST consens	ADRERSIHDF	CLVSKVVGRC	RASMPRWYN	VTDGSCQLFV	YGGCDGNSNN	50
PCR clone	ADRERSIHDF	CLVSKVVGRC	RASMPRWYN	VTDGSCQLFV	YGGCDGNSNN	50
λcDNA clone	ADRERSIHDF	CLVSKVVGRC	RASMPRWYN	VTDGSCQLFV	YGGCDGNSNN	50
EST consens	YLTKEECLKK	CATVTENATG	DLATSRNAAD	SSVPSAPRRQ	DSEDHSSDMF	100
PCR clone	YLTKEECLKK	CATVTENATG	DLATSRNAAD	SSVPSAPRRQ	DSEDHSSDMF	100
λcDNA clone	YLTKEECLKK	CATVTENATG	DLATSRNAAD	SSVPSAPRRQ	DSEDHSSDMF	100
EST consens	NYEEYCTANA	VTGPCRASFP	RWYFDVERNS	CNNFIYGGCR	GNKNSYRSEE	150
PCR clone	NYEEYCTANA	VTGPCRASFP	RWYFDVERNS	CNNFIYGGCR	GNKNSYRSEE	150
λcDNA clone	NYEEYCTANA	VTGPCRASFP	RWYFDVERNS	CNNFIYGGCR	GNKNSYRSEE	150
EST consens	ACMLRCFRQQ	ENPPLPLGSK	<u>VVYLAGLFVM</u>	<u>VLILELGASM</u>	<u>VYLIRVARRN</u>	200
PCR clone	ACMLRCFRQQ	ENPPLPLGSK	<u>VVYLAGLFVM</u>	<u>VLILELGASM</u>	<u>VYLIRVARRN</u>	200
λcDNA clone	ACMLRCFRQQ	ENPPLPLGSK	<u>VVYLAGLFVM</u>	<u>VLILELGASM</u>	<u>VYLIRVARRN</u>	200
EST consens	QERALRTVWS	SGDDKEQLVK	NTYVL			225
PCR clone	QERALRTVWS	FGD				213
λcDNA clone	QERALRTVWS	SGDDKEQLVK	NTYVL			225

[illegible]

32/48

Purification of Placental Bikunin using Superdex 75 Gel-Filtration

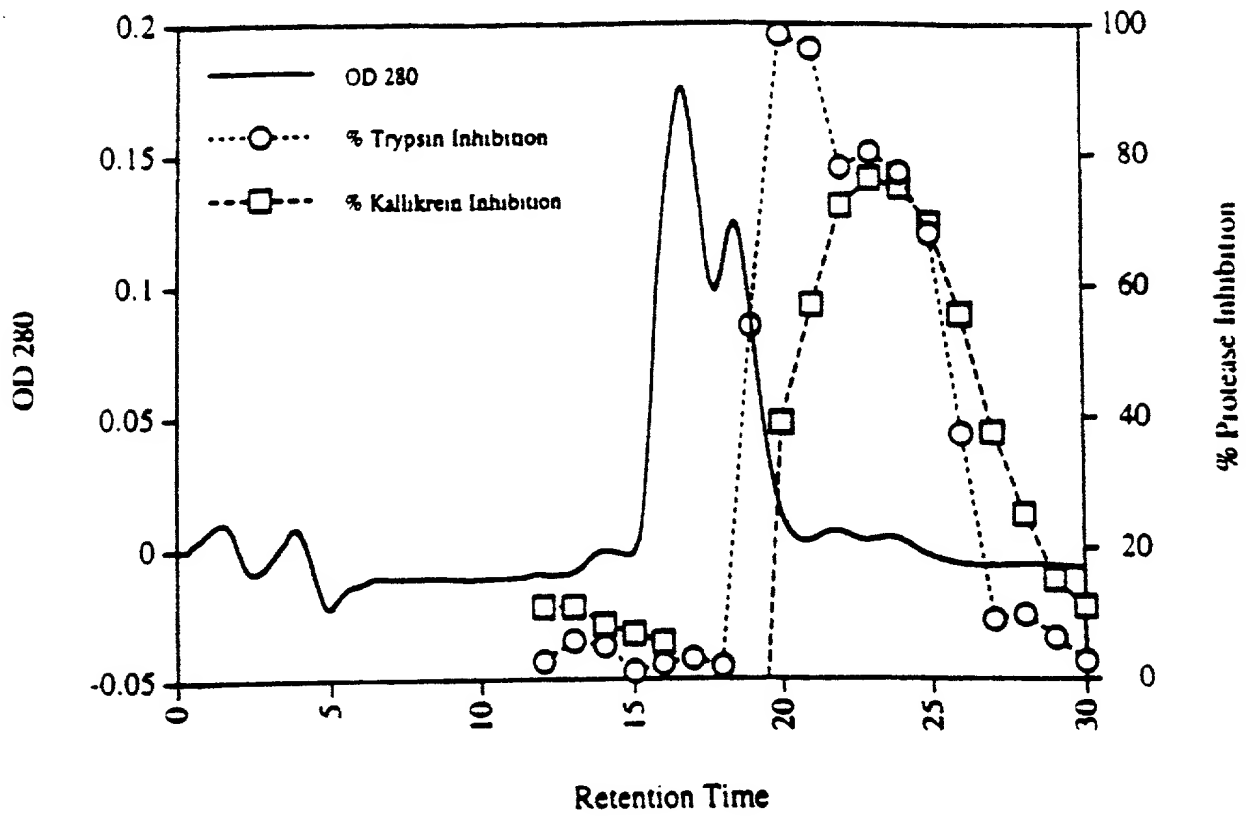


FIGURE 5

33/48

OD 215

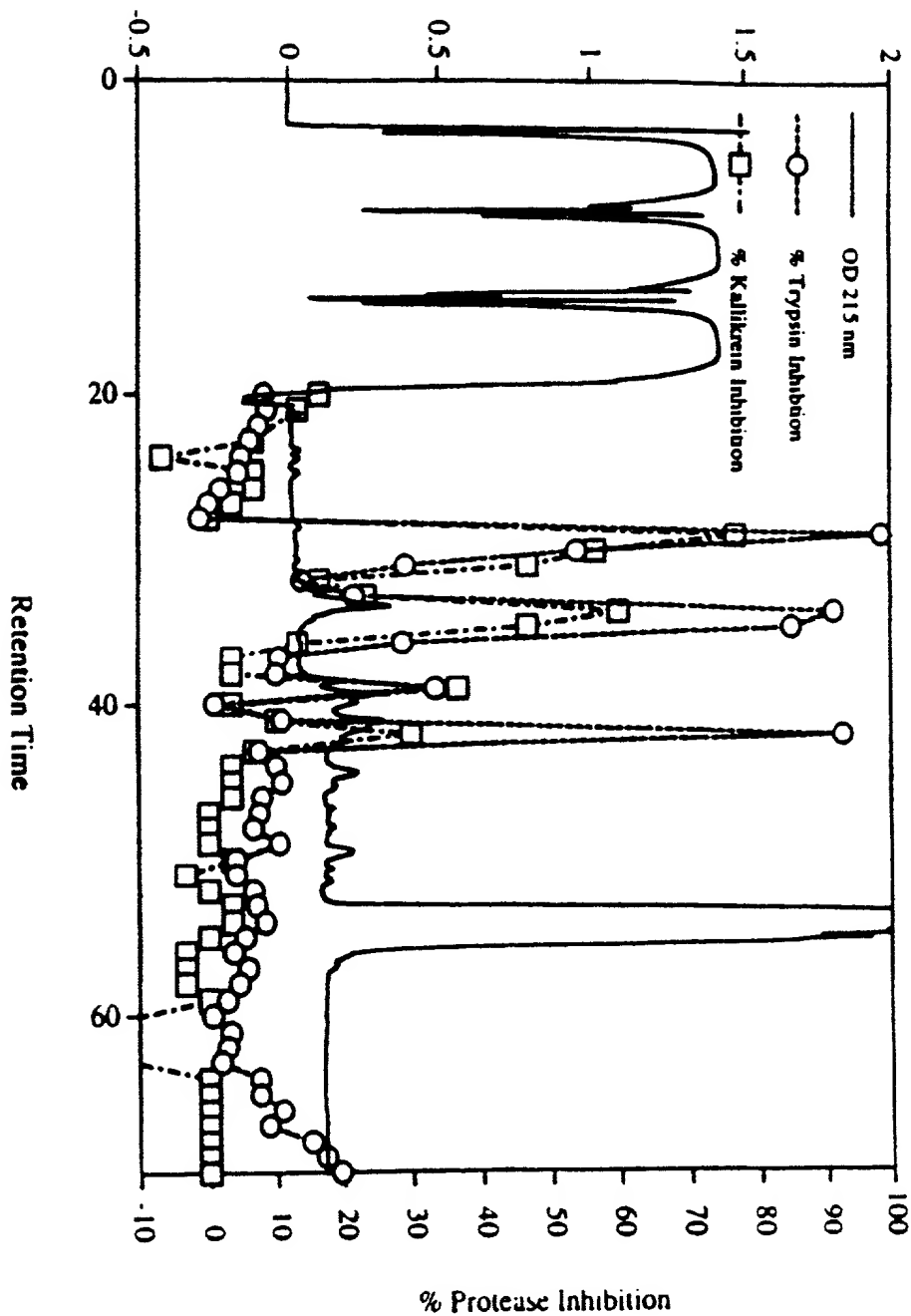


FIGURE 6

Purification of Placental Bikunin using C18 Reverse-Phase Chromatography

09243943 16000000

34/48

Figure 7

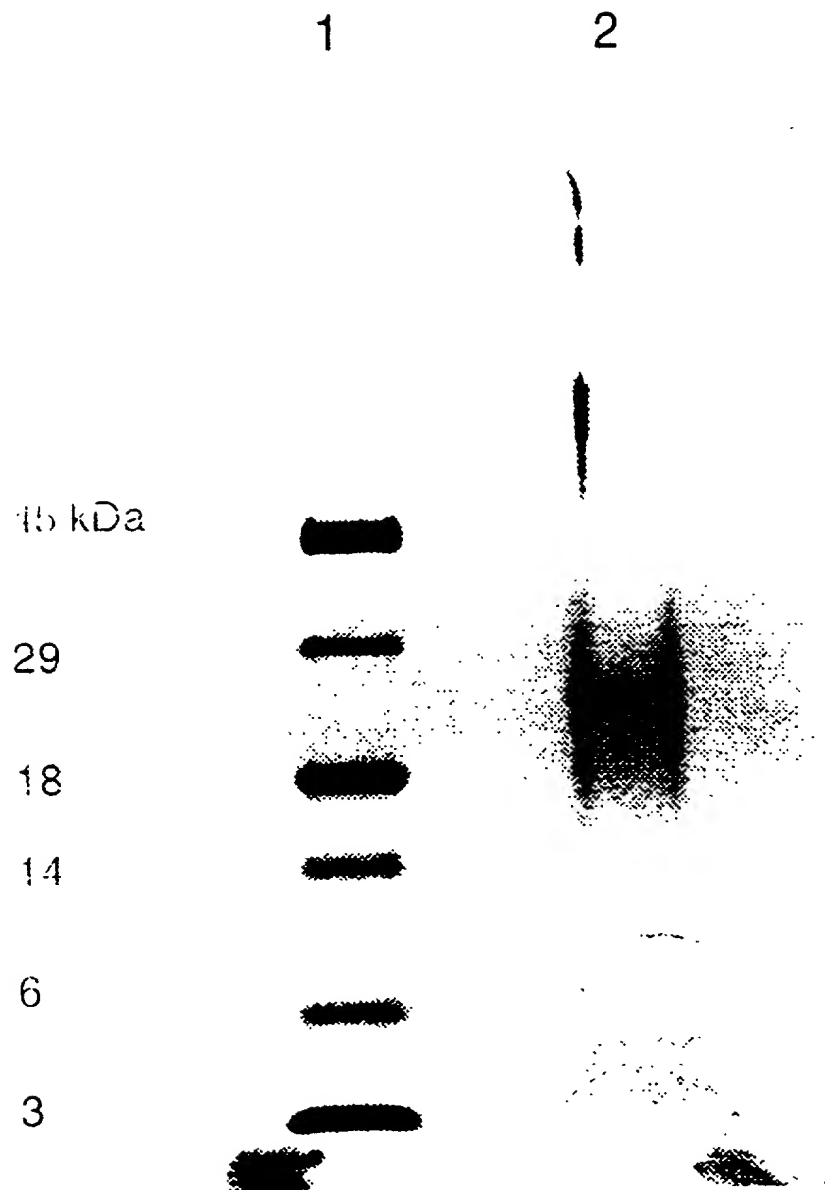


Figure 8A

35/48

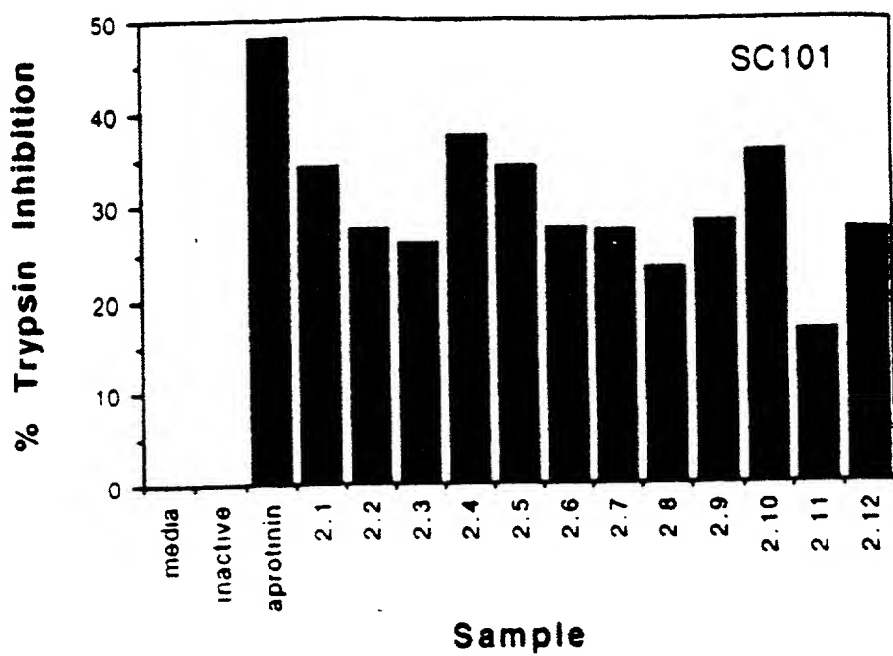
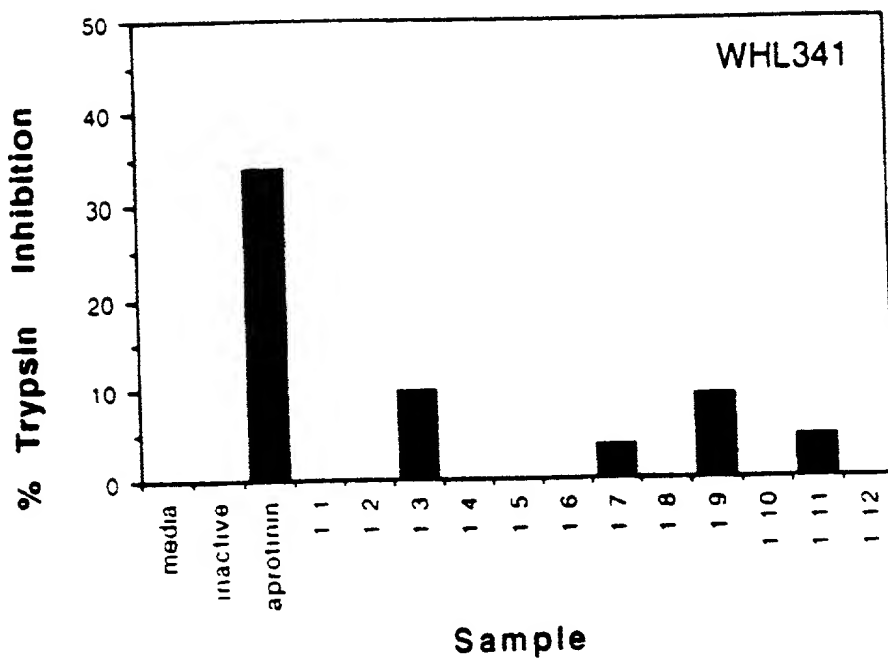


Figure 8B



36/48

Figure 9A

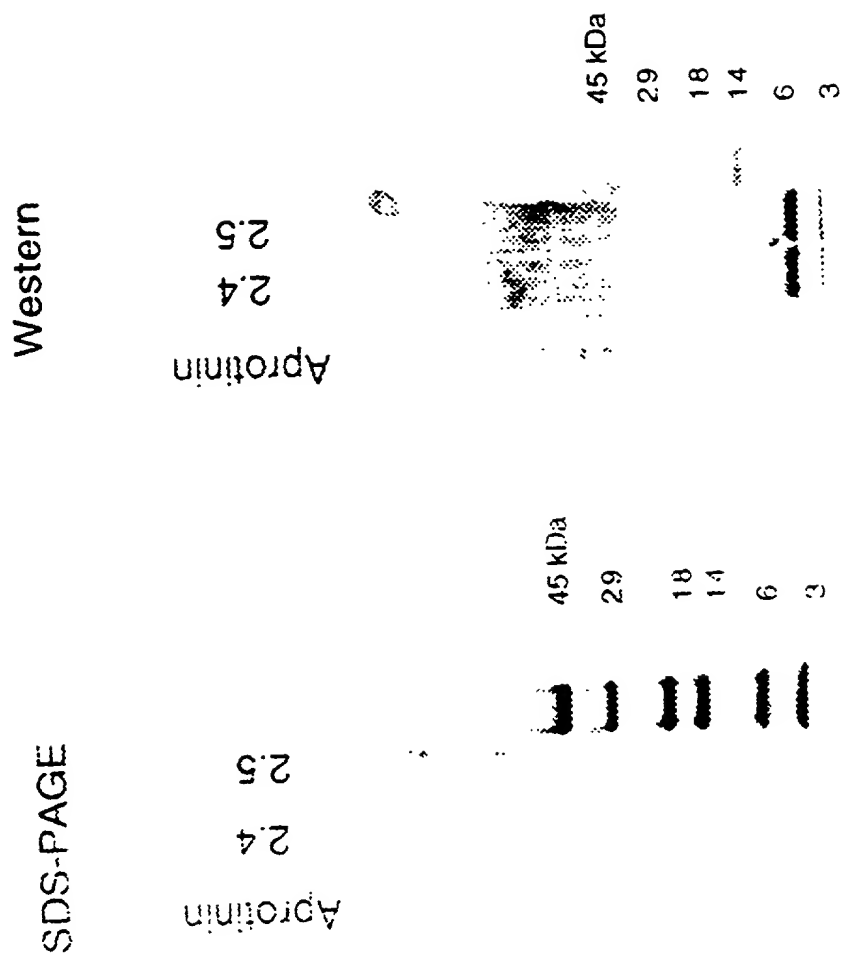
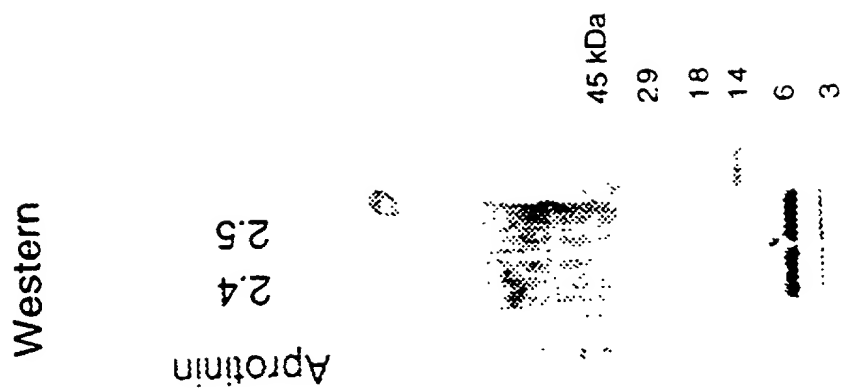


Figure 9B



37/48

Figure 10

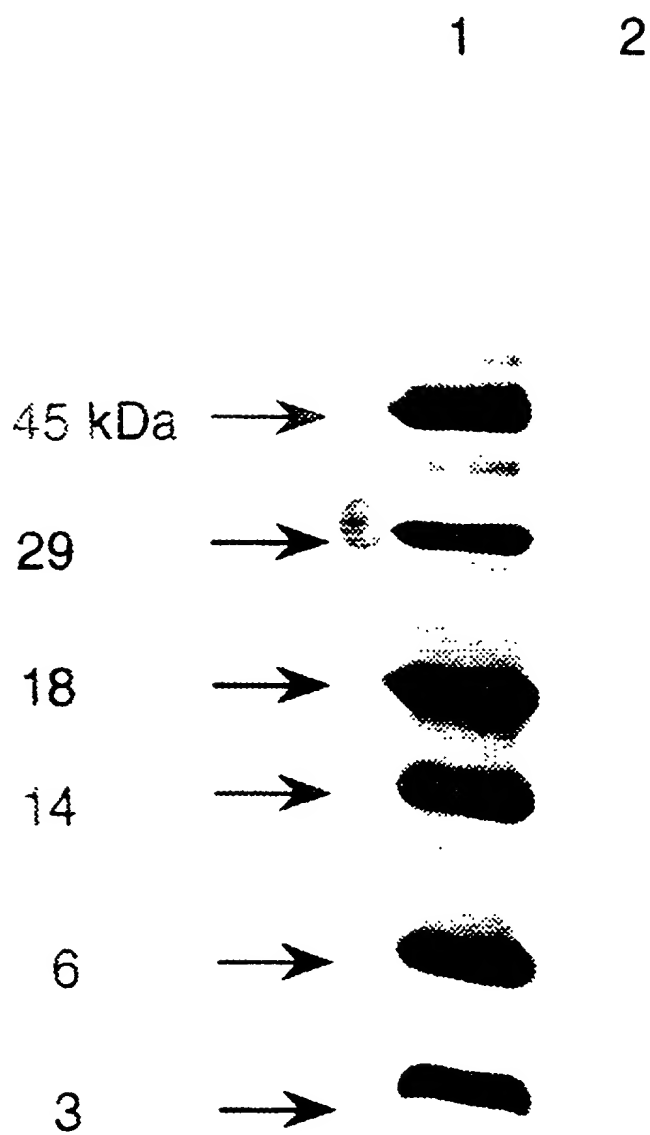


Figure 11A

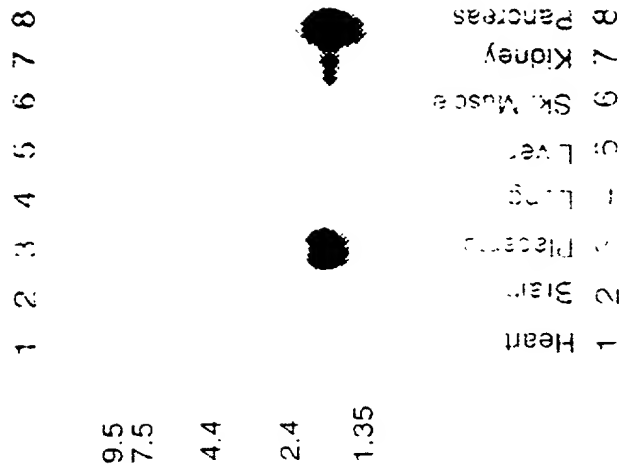
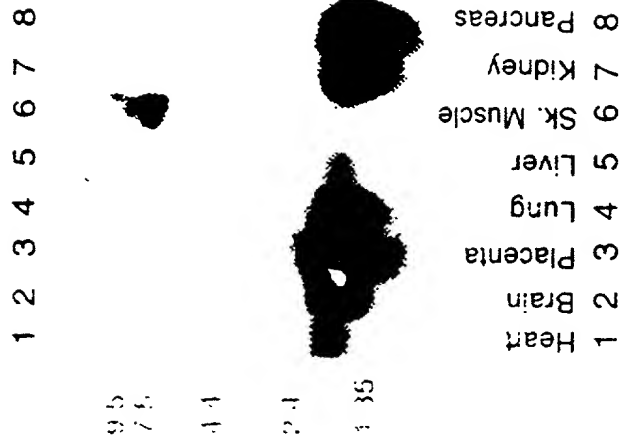


Figure 11B



8/4/88

Figure 12A

1 2 3 4

45 kDa
29
18
14
6
3

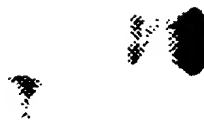


Figure 12B

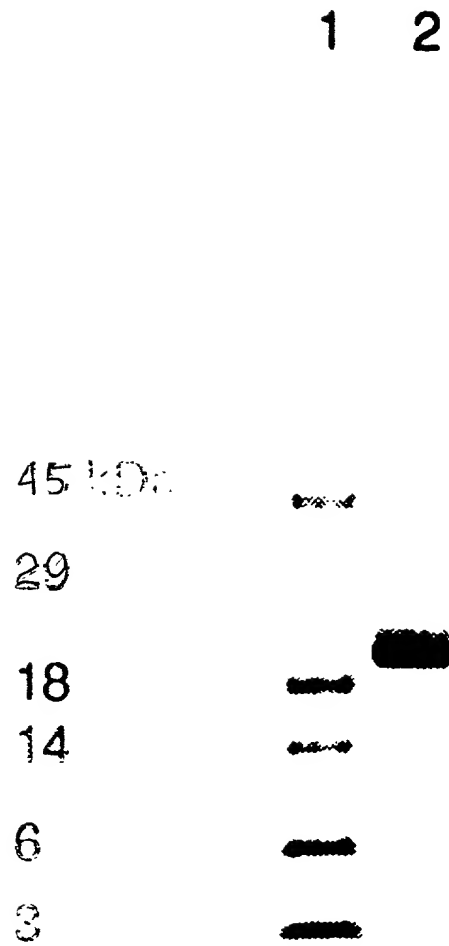
1 2 3 4

45 kDa
29
18
14
6
3



40/48

Figure 13



41/48

Figure 14

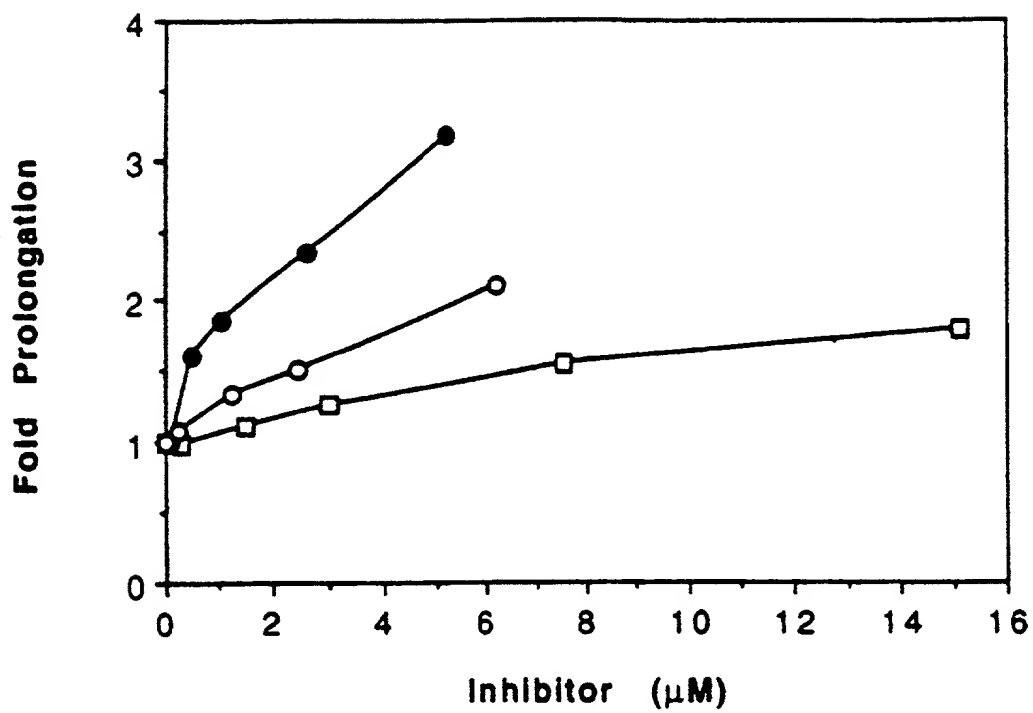


Figure 15: The effect of BIKUNIN (0.2-2µM) and amiloride (100µM) on tracheal potential difference (TPD) 3 hours post treatment

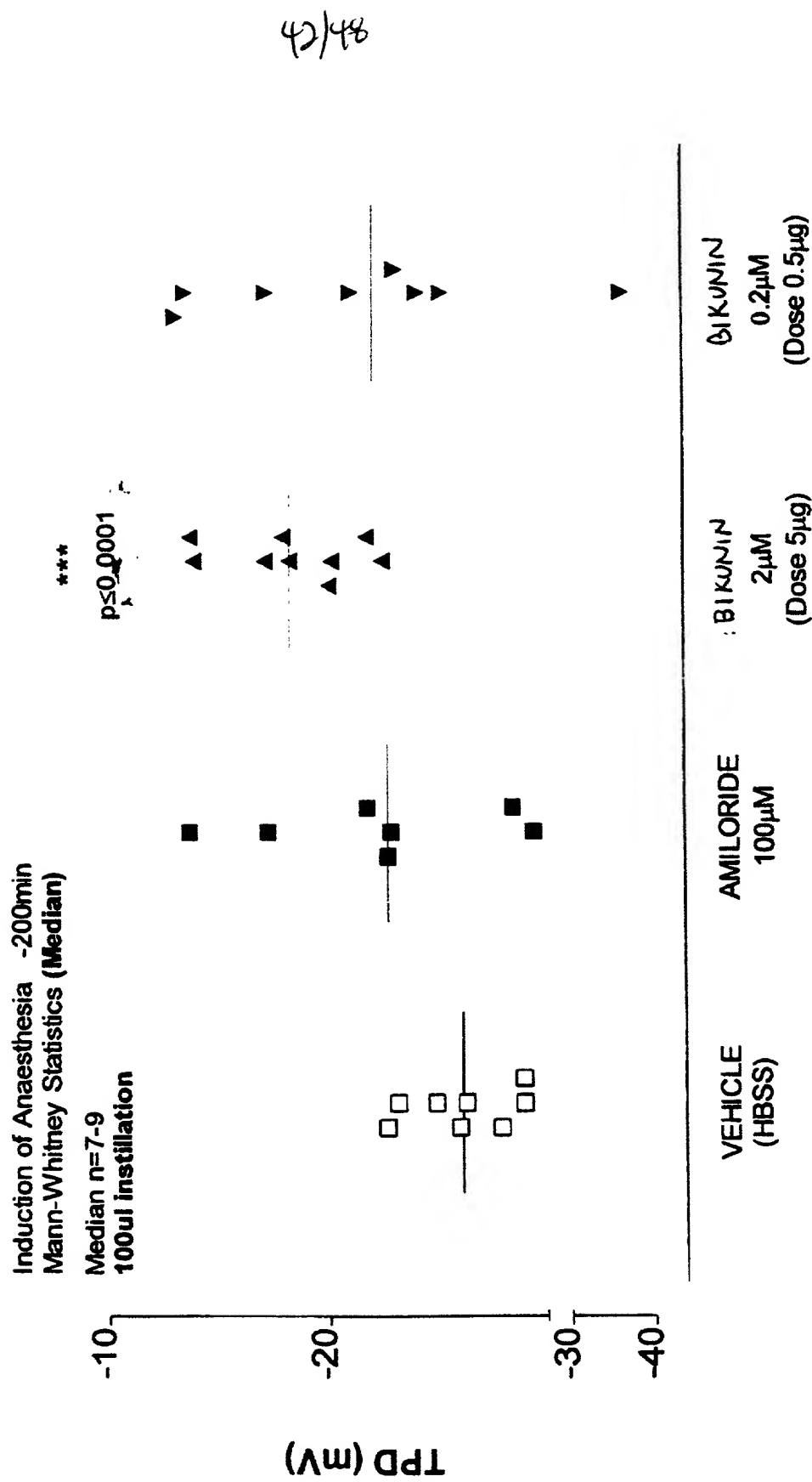
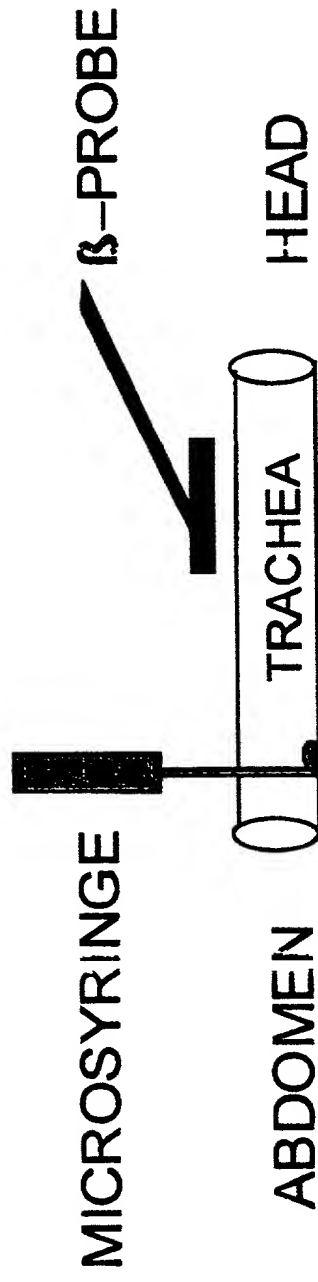


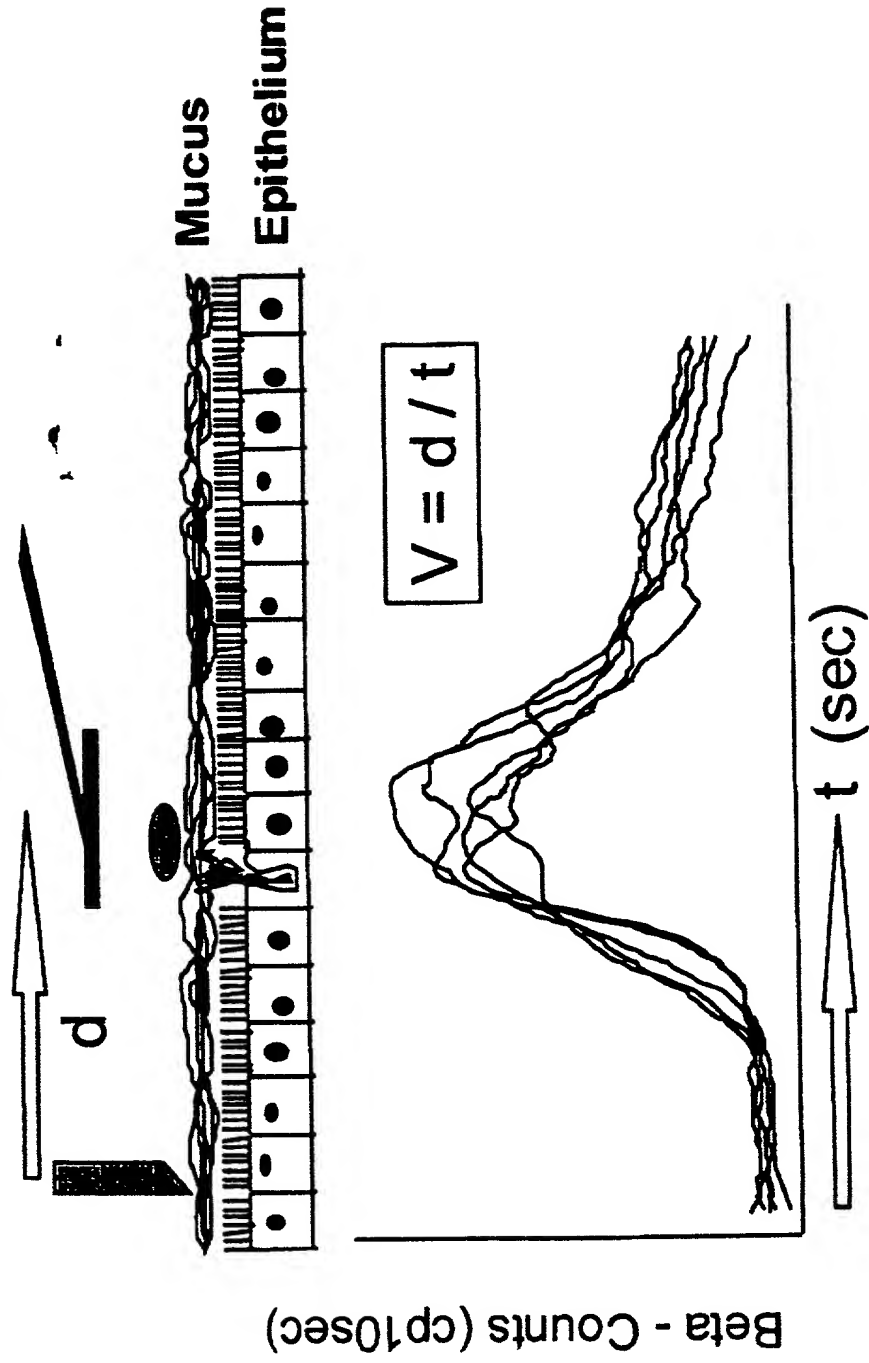
Figure 16 (a) : Diagram to show the arrangement of needle and Beta probe.



43/48

Longitudinal view

Figure 16 (b) : Counts detected by the probe as the ^{32}P -labeled Saccharomyces cerevisiae are transported along the tracheal mucociliary layer.



44/48

Figure 17 : Short circuit current (Isc) trace to show the action of Bumetanide (70nM) on sodium dependent current in cultured normal human bronchial epithelial cells in vitro

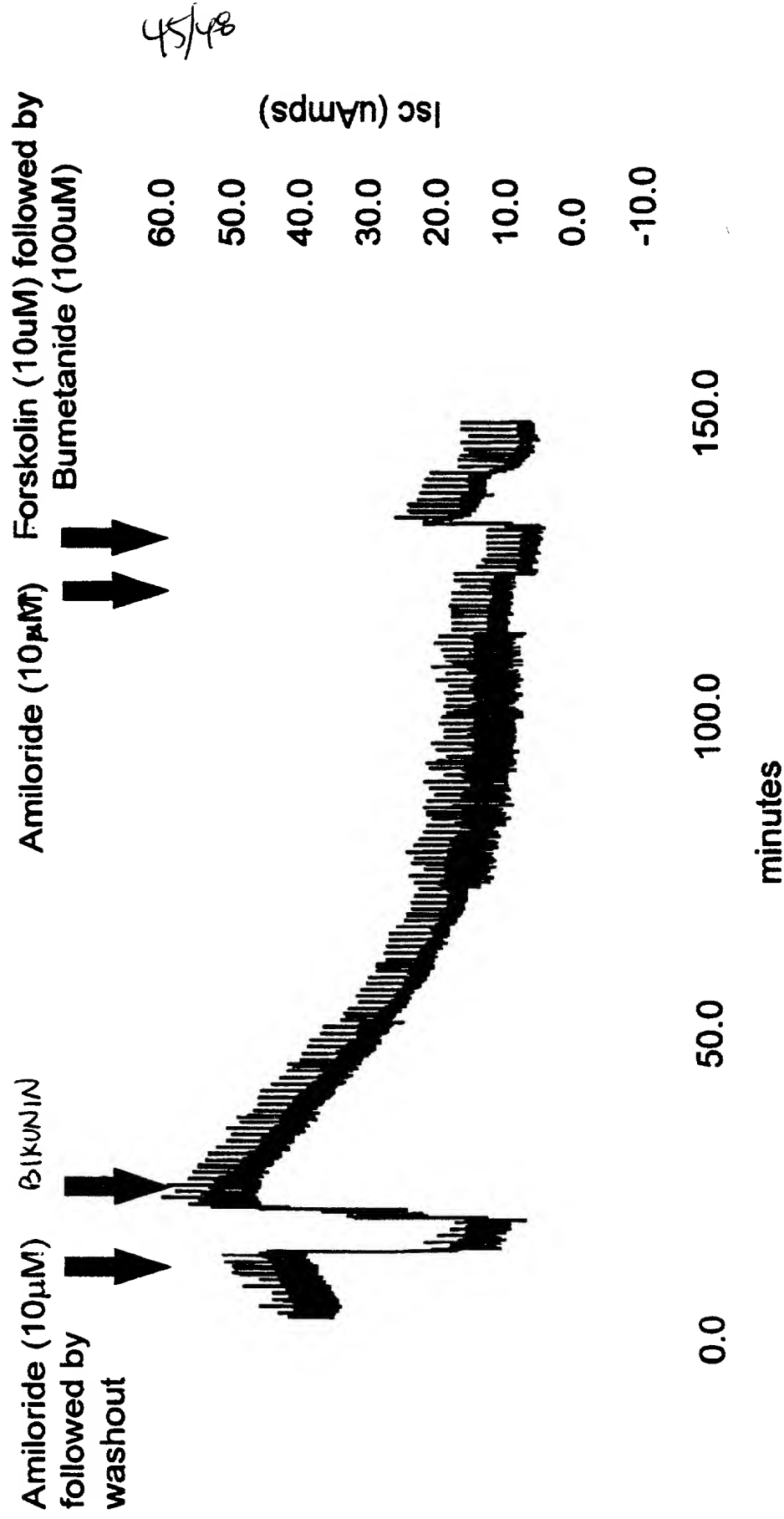


Figure 18 : The effect of a 5 min aerosol of hypertonic saline (14.4%) on tracheal mucus velocity (TMV) in the anaesthetised spontaneously breathing guinea-pig

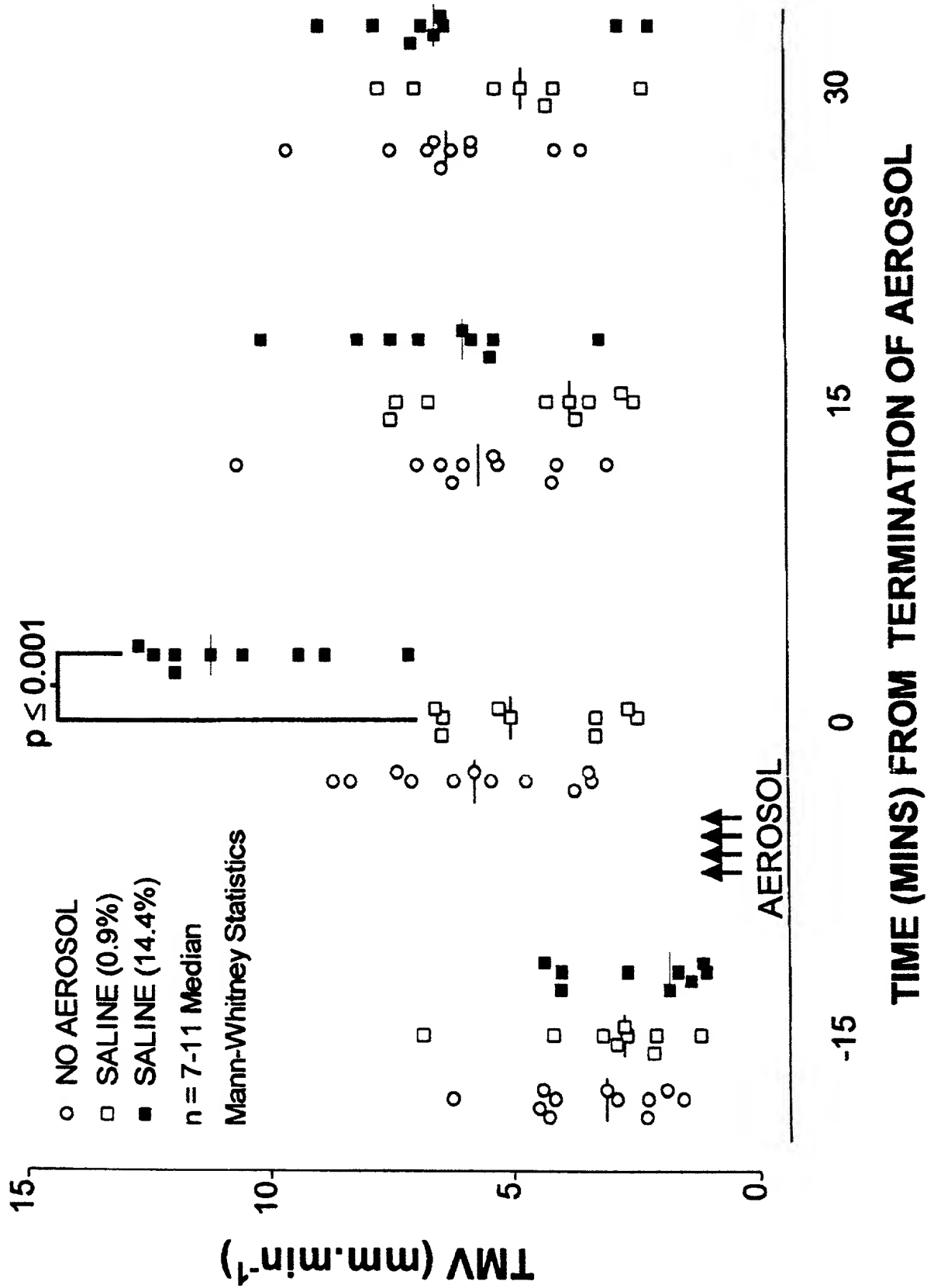
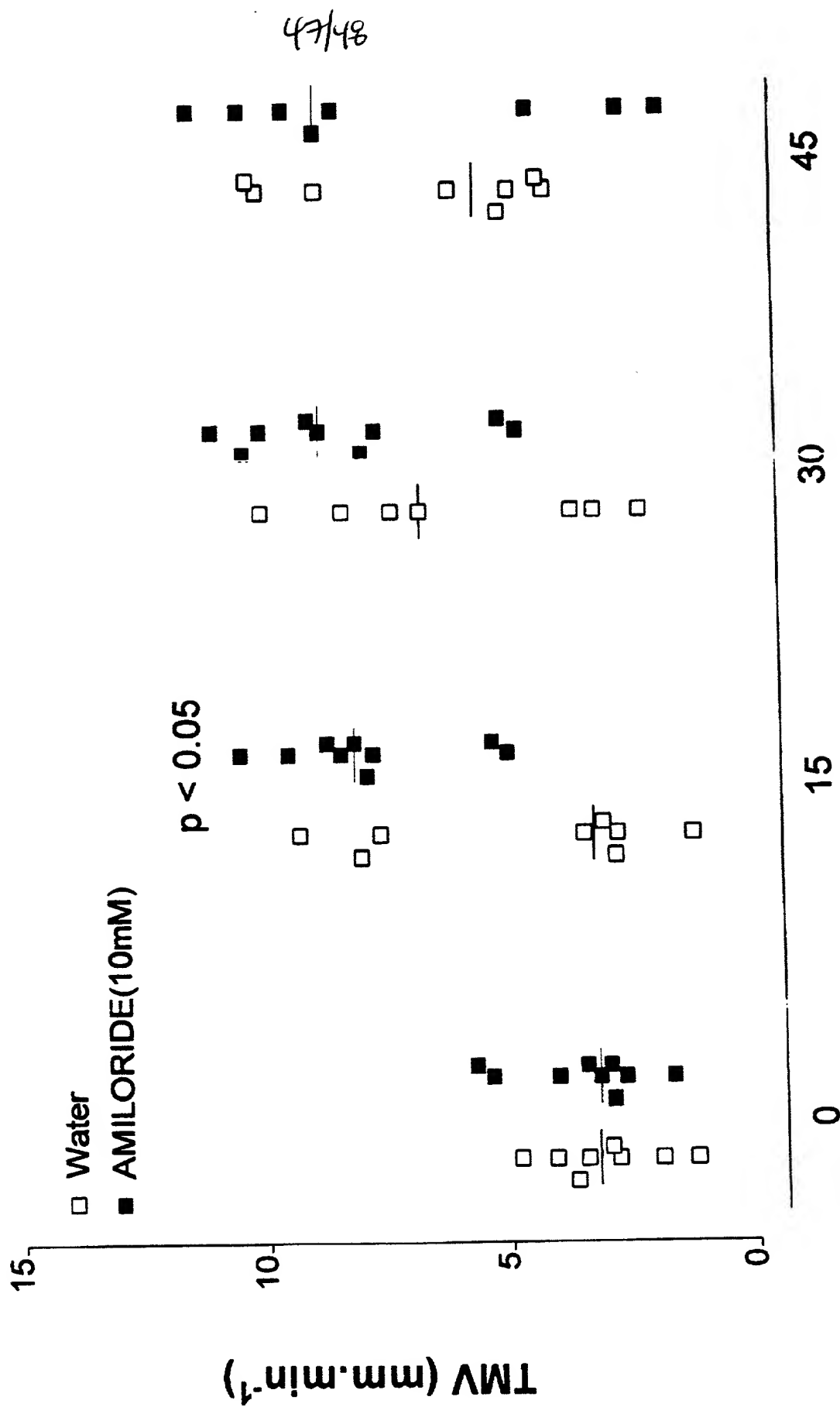


Figure 19 : The effect of a 20 min aerosol of amiloride (10mM) on tracheal mucus velocity (TMV) in the anaesthetised spontaneously breathing guinea-pig



42/48

Figure 20 : Short circuit current (Isc) trace to show the action of Aprotinin Double
mucin (0.5-5ug.ml-1) on sodium dependent current in normal human
bronchial epithelial cells in vitro

